TECHNOLOGY ROADMAP

EFFICIENTLY POWERING A HEALTHIER AMERICA

BUILDINGS CHP

DISTRIBUTED ENERGY RESOURCES

VISION 2020:

By the year 2020, Buildings: Cooling Heating and Power (BCHP) will be the preferred method of energy utilization in buildings.

BCHP will improve the indoor environment, conserve resources and reduce emission rates through energy system integration.

"This Roadmap is not a snapshot fixed in time, but an evolving partnership plan between DOE, industry and academia that is regularly revisited and modified to reflect up-to-date market realities, regulatory issues, scientific discoveries and the latest developments in technology."

William Parks
Associate Deputy Assistant Secretary
Office of Power Technologies
Energy Efficiency and Renewable Energy
U.S. Department of Energy

"The BCHP Initiative represents a major milestone toward integrating energy supply, conversion and utilization within a building. BCHP also represents the potential for a 40% efficiency improvement, the ability to meet 50% of the Kyoto Protocol goal for commercial buildings and, at the same time, significantly improve IAQ."

Joel Anderson
BCHP Initiative Chair
Senior Vice President
Mississippi Valley Gas Company

Forward

Energy is the driving force of our economy impacting every facet including chemicals, pharmaceuticals, manufacturing, healthcare, where we work, where we learn and where we play. Cooling, heating and humidity control systems are essential to business, education, healthcare and life in general. In fact, one of the single major uses of energy in buildings is for space conditioning[1].

Through the use of BCHP systems there is a distinct opportunity to significantly conserve energy, preserve natural resources and reduce climate change gas emissions by accelerating the use of BCHP systems in buildings. BCHP has the potential to increase energy efficiency dramatically and reduce carbon and air pollutant emissions. BCHP systems produce electric or shaft power and useable thermal energy onsite or near site, converting as much as 80% of the fuel into useable energy.

Commercial Buildings consume 27% of the electricity produced in the United States[2]. For each gigawatt-hour of electricity consumed approximately two gigawatt-hours of energy are lost to the environment. BCHP systems can provide power to buildings and recovered energy can be used for cooling, heating, humidity control, domestic hot water or other uses in today's buildings. Generating energy on-site or near-site avoids transmission and distribution losses, allows recovery of thermal energy and defers expansion of the capacity of the electricity transmission grid. Therefore, BCHP provides the means for recovering up to one-and-a-half gigawatt-hours of energy for each gigawatt-hour consumed.

However, Energy consumers are primarily concerned with the price, reliability, and quality of gas and electricity supplied to their homes and business. Energy efficiency and air emissions are a primary concern of the Department of Energy. Several trends in the electric industry indicate that electricity prices for residential and commercial users may rise. Peter Fox-Penner in his industry recognized book[3] on electric deregulation predicts that electricity prices may increase due to supply shortages, stranded cost recovery, and utility market power. A shortage in electricity supply may be one of the primary contributors to sustaining and possibly rising electricity prices. DOE EIA projects that the US will need to build over 360 gigawatts of new electric capacity to meet growing demand and compensate for plant retirements.

Without changes to current policy most of the projected 360-gigawatt shortfall will be met with low efficiency, simple and combined cycle gas turbines. California and Illinois have requests for over 20,000[4] and 8,000[5] megawatts of new electric capacity, respectively. This new capacity is planned as combined and simple cycle gas turbines with overall efficiencies in the range of only 45%.

BCHP is an effective solution to offset growing electricity demand, shaving peak loads, and increasing electricity supply, all of which will help stabilize electricity prices and improve electric grid reliability. BCHP will also significantly increase energy efficiency and lower air emissions.

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[1] Cooling, ventilating and heating
[2] Annual Energy Outlook 1999, DOE/EIA-0383, December 1998
[3] Electric Utility Restructuring: A Guide to the Competitive Era, Peter Fox-Penner, 1998
[4] Based on a conversation with California Energy Commission, Commissioner David Rohy.
[5] Illinois State Environmental Protection Agency

Introduction

The Department of Energy has embarked on significant partnerships with industry with the intent of creating meaningful research, development and commercialization roadmaps. Reviewing progress among these important efforts, the natural gas industry, manufacturing trade allies in the onsite power generation and thermally activated HVAC industry concluded that a significant technology synergy exists. To address this opportunity, industry has created the BCHP Initiative and is proposing the BCHP 2020 Vision in support of the Department's Distributed Energy Resources Roadmap and the Whole Commercial Building Roadmap.

This Roadmap is not a single snapshot fixed in time, but an evolving program plan that is regularly revisited and modified to reflect up-to-date market realities, regulatory issues, scientific discoveries and the latest developments in technology.

The BCHP Initiative will be defined by agreement on priorities, new collaborative commitment to the acceleration of research and development and the implementation of results. Success will only occur with agreement in partnership, sharing of resources and a new level of trust between industry, government and academia resulting in an endeavor dedicated to achieving BCHP implementation as a national imperative.

BCHP is part of a broader program undertaken by the Department of Energy's Office of Power Technology. The Office of Power Technology (OPT) works with industry to increase the opportunity for Distributed Energy Resource (DER) system use in America. DER systems offer substantial energy efficiency, economic, environmental and energy security benefits to our nation. Assistant Secretary Dan W. Reicher announced, at the CHP (Combined Heat and Power) Summit on December 1, 1998, a national goal to double the amount of DE capacity by 2010. This means adding approximately 46 GW of new DP capacity. The Environmental Protection Agency and the U.S. Combined Heat and Power Association have agreed to work with the Distributed Power Initiative to achieve this goal.

The BCHP Initiative will identify opportunities and barriers to applying a wide range of BCHP technologies to buildings and will seek out appropriate actions among the growing number of industry, institutional and governmental entities focused on the broader Distributed Generation marketplace.

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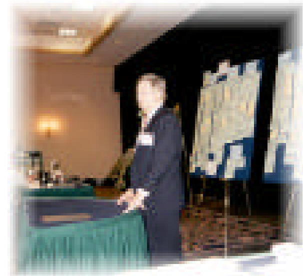
The Roadmap

The Beginning - A Vision of the Future



This document represents the evolution of six major workshops covering the following strategic issues:

Visioning Workshop (March 11 & 12, 1999)
Roadmapping Workshop (June 1, 2 & 3, 1999)
Technology Workshop (November 8 & 9, 1999)
Market Workshop (January 12 & 13, 2000)
Policy Workshop (March 20 & 21,2000)

The objective of the workshops was to develop a technology/market/policy roadmap for BCHP applications. Over two hundred[6] technical and policy experts representing manufacturers, utilities, building operators, research and development organizations, industry associations, ESCOs, engineers, universities and national laboratory personnel worked together to define their vision for on-site/near-site power generation, energy recovery, energy management and utilization for commercial, institutional, multifamily and community based buildings.

An achievable energy future for the 21st century was viewed as essential to firmly place the American economy into the forefront of the Internet information age. The BCHP working group saw a clear destination and has constructed a roadmap to avoid detours, obstructions and accidents along the way to its destination in the year 2020. The guiding principles for the BCHP Roadmap are:

Need for a responsive and reliable energy infrastructure requiring a portfolio of solutions for improving efficiency, resource conservation and the environment

Significant use of BCHP systems for increased power quality, reliability, efficiency improvement and emissions reductions

Improvements in conventional generation options

Continuing improvements within the electric grid

Provide a higher quality of life for all Americans by managing the indoor environment for efficiency and optimum personal health, productivity and comfort by managing temperature, humidity, particulates, bioeffluents, volatile organic compounds, noise and light to each individual's benefit while providing business with flexibility and economic advantage to perform.

BCHP Vision Statement

By the year 2020, Buildings: Cooling Heating and Power systems will be the preferred method of energy utilization in buildings.

BCHP technology will improve the indoor environment, conserve resources and reduce emission rates through energy system integration.

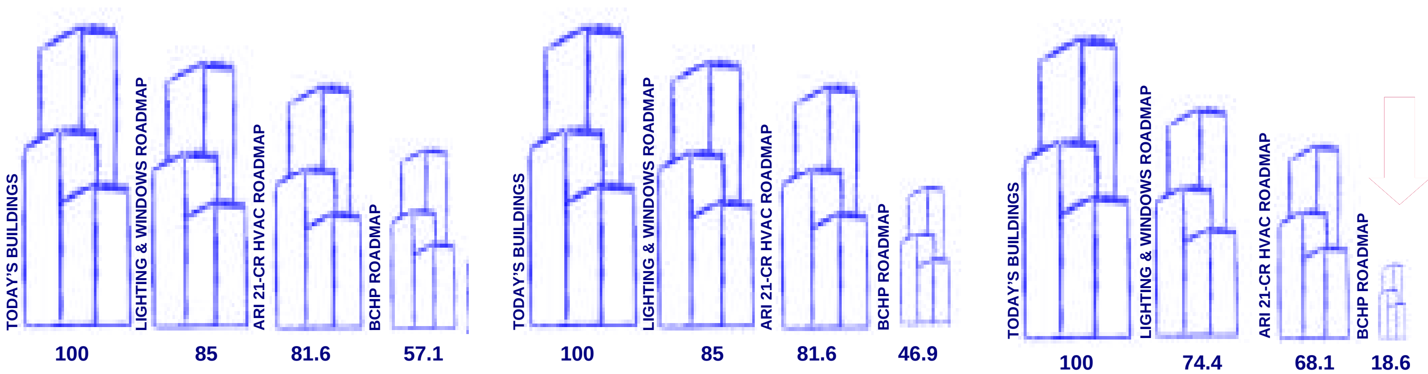
[6] Cumulative attendees of the Visioning, Roadmapping, Technology, Market and Policy Workshops.

BCHP National Potential

Depending on the choices we make, innovations made possible by this effort can help America improve the world we live in and continue to expand our economy over the next 20 years:

Significantly improve Building Resource-based Energy Efficiency [7]

BCHP efficiency improvement, through the use of recovered energy, would yield about a 30% natural resource saving.



% ENERGY USE vs STATUS QUO | **% CO_2 EMISSIONS vs NATIONAL AVERAGE** | **% CO_2 EMISSIONS vs COAL PLANT**

Significantly reduce Greenhouse Gas emissions

BCHP is projected to contribute to 50% of the current Kyoto Protocol reductions if implemented and supported in accordance with this Roadmap.

Reductions	1990	1995	2000	2005	2010	2015	2020
Base Case	0	0	0	0	0	0	0
Lighting+Windows+ARI 21CR	0	0	0	0	7	13	20
BCHP	0	0	0	13	31	47	63
Kyoto Goal[8]	15	33	51	69	84	98	113
BCHP/Kyoto Goal	-	-	-	18.8%	36.9%	48%	55.8%

Avoided CO_2 Emissions in Millions of Metric Tons (MMT)[9]

Significantly improve Indoor Air Quality (IAQ)

BCHP can effectively integrate desiccant dehumidification and enthalpy exchange devices with thermal cooling, heating and storage devices that will dramatically accelerate their use in buildings and thereby lead to proper ventilation air rates and proper control of building moisture levels.

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[7] BCHP efficiency improvement would yield about 30% building energy consumption reduction (in addition to the ongoing Lighting Roadmap and ARI 21-CR Roadmap) directly leading to a 45% CO2 reduction versus the national average generating mix and 77% CO2 reduction versus a coal power plant. (See Appendix D for details)

[8] Kyoto Goal refers to the total Greenhouse Gas emissions reduction target for the USA for Commercial and Institutional Buildings from all sources and proper implementation of BCHP can have a major impact on meeting these goals. (See Appendix D for details)

[9] Assumes 4% BCHP retrofit market penetration beginning in 2005, 25% BCHP market penetration in new buildings beginning in 2005 and 50% market penetration in 2010. (See Appendix D for details)

BCHP Strategic Performance Targets

Strategic Performance Targets were developed through a deliberative process that began with the first Visioning workshop. The same methodology was used during the Roadmapping workshop. The Roadmap workshop divided into four technology breakout sessions focusing on the four principle technology disciplines involved in BCHP: power generation, cooling/heating, dehumidification & IAQ, and controls & system integration.

The process began with establishing barriers to achieving any level of success in the marketplace. The barriers are identified through a facilitated session and generally created extensive lists. (See Appendix A for detailed lists of barriers for the four breakout groups). The barriers were then logically grouped by category (i.e. reliability, cost, policy, marketplace issues, etc.) and then prioritized by the breakout groups. Prioritization is accomplished by issuing a limited amount of votes to each participant in two classes (top priority and importance). Each participant is free to vote in any manner including all votes on a single issue.

The actions to overcome the barriers are then identified through a facilitated session by having each member of the breakout group listing three actions. (See Appendix A for detailed lists of actions to overcome the barriers for the four breakout groups). The actions to overcome the barriers were then logically grouped by category (i.e. policy, R&D, education, etc.) and then prioritized by the breakout groups. Prioritization is again accomplished by issuing a limited amount of votes to each participant in two classes (top priority and importance). Each participant is free to vote in any manner including all votes on a single issue. Timeframes are then placed on each action and lead partners (industry, associations, government and academia) are assigned.

The Roadmapping workshop began by reviewing the Vision and Strategic Performance Targets of the Visioning workshop and each breakout group made modification to these goals (See Appendix C). The actions to overcome the barriers and timeframes are then rationalized with initial Strategic Performance Targets to form the Consensus Strategic Performance Targets, which are the backbone of the Roadmap.

The BCHP Consensus Strategic Performance Targets

Year 2000

- Technical/Policy Roadmap acceptance by all partners
- Complete market and technology assessment
  - Establish Performance Targets for the following:
    - Resource Efficiency
    - Indoor Air Quality
    - Reliability
    - Capital Cost
    - Life-cycle Cost
    - Support
    - Interoperability
- Benchmark market penetration, develop market tracking metrics and establish aggressive market growth targets
- Establish BCHP information exchange
- Establish source energy efficiency metric for buildings

Define needs for and initiate development of tools and education about choices and benefits of BCHP for the design community, contractors, energy providers and building owners/decision makers

Begin education of federal and state policy makers on BCHP and create a support system for BCHP within other Federal programs (e.g. Rebuild America, FEMP, OMB, GSA, EPA, etc.)

Begin education of building owners, engineers, architects, design/build consulting engineers and contractors and other decision makers about choices and benefits of BCHP through case studies, financial based analysis, etc.

Reality check of aggressive nature of goals

Year 2002

Pass executive order to mandate BCHP usage in all new federal buildings and major rehabilitation projects that meet a proscribed economic hurdle rate.

Reduce risk to the design community through development of design tools, evaluation, software, case studies, etc.

Awareness of value/demand will reach 25% of target decision makers

Measure through feedback cards, focus groups and surveys the success of education programs directed toward building owners, engineers, architects, design/build consulting engineers and contractors and other decision makers about choices and benefits of BCHP through case studies, financial based analysis, etc.

Measure through feedback cards, focus groups and surveys the success of education programs directed toward federal and state policy makers on BCHP

Reality check of aggressive nature of goals

Year 2005

Recognized and accepted source energy efficiency metric is established

Favorable regulatory environment is established - include tariff, interconnect and local air quality board issues

Market based emissions mechanism is established

GRID interconnection requirement is standardized

Economically viable benefits and penalties for resource conservation, atmospheric emissions and indoor air quality

ASHRAE 62 compliance enforcement

100 demonstration sites

10% of federal buildings use BCHP

Awareness of value/demand will reach 50% of target decision makers

Reality check of aggressive nature of goals

Year 2010

25% of new commercial/institutional buildings use BCHP

4% of existing commercial/institutional buildings use BCHP

20% of federal buildings use BCHP

Awareness of value/demand will reach 75% of target decision makers

Achieve 20% reduction in energy use with controls

Commercially available control algorithms (hardware and software) able to achieve 80% of optimal cost savings

Match or exceed reliability of existing utility services

Reduce life-cycle cost by 20%

95% customer satisfaction
Achieve full interoperability with control systems from major manufacturers
Reduce power system costs
- Field cost of $1000/kW
- Of installation
- Life cycle

Improve power system efficiency of electricity generation to > 40% HHV and BCHP efficiency > 90% HHV
Reality check of aggressive nature of goals

Year 2020

50% of new commercial/institutional buildings use BCHP
10% of existing commercial and institutional buildings use BCHP
BCHP becomes the low cost method of providing electricity and HVAC&R services for buildings in America
Plug and Play controls
Deploy BCHP in federal buildings (e.g., 50%)

Roadmap Destinations

The Roadmap Destinations are the critical stops along the trip that must be made in order to reach our Goals. Impact, Timeframe and Lead Partners prioritize each Destination. Three Highways have been identified within each of the three Destinations: Policy, Technology and Process. Each Highway listed is a Top Priority. The Roadmap's structure is depicted on the following page and is designed to serve as a model and provide guidance for the development of process, technology and process research, development, demonstration and commercialization projects.

Impact on success of BCHP Roadmap is indicated in three degrees:

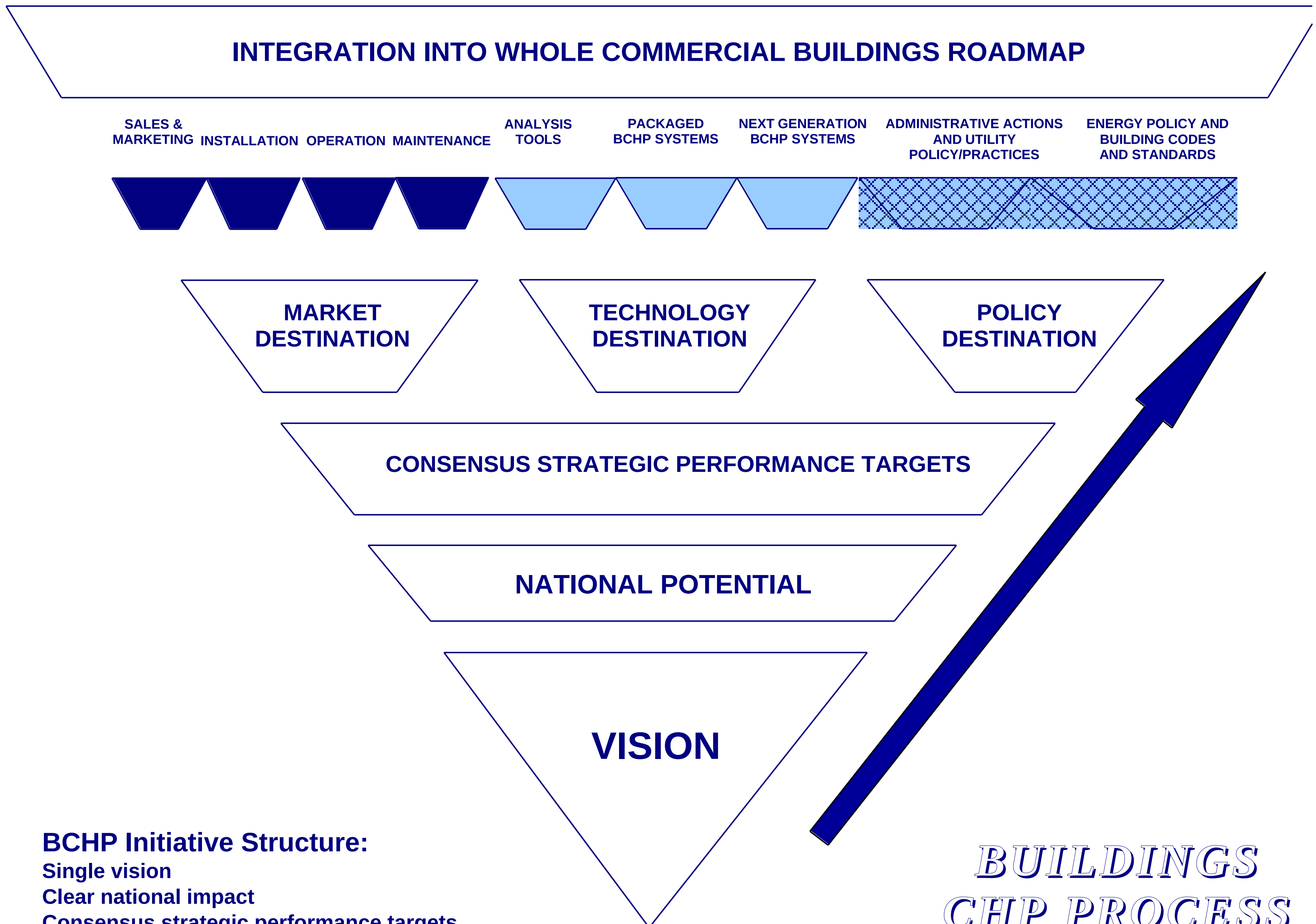
Top Priority 1 Priority 2 Important 3

Timeframes are indicated in three intervals:

Immediate 0 to 3 years 1 Mid-term 3 to 6 years 2 and Long-term 6 to 10 years 3

Lead Partner or Partners indicated by the following:
(Note if two or more Partners are listed, they are listed in order of contribution to reaching the Destination)

Industry I Government G Association A Academia ac



BCHP Initiative Structure:
Single vision
Clear national impact
Consensus strategic performance targets
Three destinations to reach
Three highways to travel to reach each destination

BUILDINGS CHP PROCESS

Technology Destination
12/99 (Rev 5)

The Technology Destination is the final result of a two-day program-planning workshop held in Chicago, Illinois, on November 8-9, 1999. The purpose of the workshop was to develop program and project ideas and priorities for implementing the Building Cooling, Heating, and Power (BCHP) Roadmap developed at a roadmapping workshop held earlier this year.

This is the first program-planning workshop, in the Technology area, and was designed to develop research, development, demonstration, and commercialization projects in a number of Technology Areas identified by the Roadmap, including:

- Analysis and Design Tools,
- Packaged Systems, and
- Grid-Independent Systems.

The goals of the Technology Program Planning Workshop were to:

- Review and modify the technology destinations in each of these three areas;
- Identify research, development, demonstration, and commercialization projects to achieve these destinations; and
- Develop start/end dates, key products/milestones, partners/performers, linkages, and specific tasks/deliverables for top priority RD&D projects.

Forty-six technical experts, representing manufacturers, utilities, building designers and operators, research and development organizations, industry associations, ESCOs, engineers, universities, and national laboratory personnel worked together to develop specific RD&D programs and projects for BCHP systems in commercial, institutional, multifamily, government, and community buildings.

Three focus questions were asked of participants, who were divided into four groups. The four groups included:

- Analysis and Design Tools for Building Cooling, Heating and Power
- Packaged Systems for Building Cooling, Heating and Power - “A”
- Packaged Systems for Building Cooling, Heating and Power - “B”
- Next Generation Building Cooling, Heating and Power Systems

The three focus questions were:

1. What modifications or improvements should be made to the technology destination identified by the ***BCHP Roadmap Document?***
2. What research, development, and demonstration programs will achieve the technology destination as modified?
3. For each top priority RD&D program, what are the start and end dates, key milestones/products, partners, linkages, and specific tasks that must be undertaken?

The four groups worked over the two-day period to discuss and answer these questions. The following chapters of this report present the results of these discussions and offer a priority list of potential programs and projects for BCHP in the coming years.

Technology Destination

Individual equipment designs being sold today can be integrated into viable BCHP installations. Commercially available gas turbines, IC engines, chillers, desiccant systems and boilers are in many cases very advanced. What is lacking is the holistic design, validation, and implementation approach that brings all these technologies into a building in an optimum manner.

By accelerating the RD&D, commercialization, and use of integrated building energy systems, BCHP will undoubtedly accelerate refinement of existing technologies, and research and development of heating, cooling, dehumidification and advanced power generation technologies. These technologies will include fuel cells, advanced gas turbines, control strategies and protocols, microturbines, advanced IC engines, and energy storage, as well as advanced energy recovery and utilization technologies

This will lead to a path of discovery, innovation, and standardization in design software, control strategies, integrated systems, new equipment design for better integration, operating strategies, and entirely new technologies.

Crosscutting Issues and Trends

TO ACHIEVE the 2020 Vision for Building Cooling, Heating and Power, improvements in software, hardware, and integration must take place. Research, development, demonstration and/or commercialization will enhance the efficiency and cost-effectiveness of individual building equipment designs currently sold in the marketplace. Each of the four Breakout Session reports at this Program Planning Workshop addresses the following issues:

The declining reliability of electric utilities due to the age of the national grid system and the cost of energy in some geographic regions of the country

- The opportunities for building cooling, heating and power to be a major part of the solution to this reliability problem
- The growth rate in electricity demand, which may allow BCHP systems to fill in the supply-demand gap
- The positive environmental impact of BCHP systems, i.e., on-site power generation, energy efficiency, advanced, high-efficiency engines, fuel cells, etc.
- Many commercial operations have “mission critical” activities that need to continue without interruption, no matter what. Users want BCHP systems to be able to provide reliable energy services so that they can focus on mission critical activities. In many cases, users will be willing to pay a premium for cooling, heating, and power systems that can operate no matter what happens to the energy grid.

Recognizing that these issues are important to the future of BCHP, a number of crosscutting program concepts and themes have resulted from Breakout Session discussions.

Case studies and demonstration projects of successful BCHP components, equipment, and systems are extremely key in illustrating the potential cost and energy efficiency improvements which result from integrated building design and construction. In all areas – hardware, software, and packaged integrated systems – working demonstrations serve to illustrate success.

In addition, development of field performance parameters, and equipment/system monitoring and diagnostics is important in measuring the quality and performance of BCHP systems in the real world. In order to reduce power generation system costs and lower emissions, and to develop more sophisticated, "plug and play" systems, measurement of field performance must be a part of software, hardware, and packaged integrated systems.

All four breakout groups similarly recommended development of system templates, protocols, and modular BCHP components and systems, to enhance the "plug and play" concept; standardized, simple control (communication) protocols, education and training for architects, engineers, and building designers, operators, component manufacturers, and occupants; development of benchmark metric studies to lead to standardized manufacturing data for heating, cooling, and ventilation equipment, and more sophisticated monitoring and diagnostics for BCHP systems. Finally, better development of BCHP cost-benefit analyses on equipment components and software were recommended as necessary for encouraging and enhancing the installation of integrated packaged systems.

Technology Workshop Programs and Funding Recommendations

The following table summarizes the cumulative program funding recommendations of the Technology Workshop participants. Note the program dollars listed would be matched by industry investment.

BCHP Package Integration	2001	2002	2003	2004	2005	Total
Development of a building demonstration program	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	30,000,000
BCHP Community Test Beds	0	2,500,000	2,500,000	0	0	5,000,000
Package Integration of Thermal Recovery Equipment	1,000,000	4,000,000	4,000,000	0	0	9,000,000
Small to Medium Air-Cooled BCHP Commercial Chiller	600,000	1,400,000	1,200,000	0	0	3,200,000
Development of modularized BCHP packages	1,200,000	4,000,000	4,000,000	0	0	9,200,000
Benchmark study to establish BCHP metrics	500,000	500,000	500,000	0	0	1,500,000
Prime mover efficiency, cost, emissions, and reliability	0	40,000,000	40,000,000	40,000,000	40,000,000	160,000,000
Standardized Control Protocol for BCHP	1,000,000	2,000,000	0	0	0	3,000,000
Development of advanced "plug & play" controls	500,000	1,000,000	1,000,000	0	0	2,500,000
Identify Other Integrated System Concepts	0	0	4,000,000	6,000,000	6,000,000	16,000,000
	10,800,000	61,400,000	63,200,000	52,000,000	52,000,000	239,400,000

Next Generation of BCHP Systems	2001	2002	2003	2004	2005	Total
Case studies (detailed) of success stories	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	5,000,000
Create a BCHP and building design clearinghouse	250,000	250,000	250,000	250,000	250,000	1,250,000
Develop BCHP monitoring software and systems	1,000,000	2,500,000	2,500,000	0	0	6,000,000
Develop plug & play systems and equipment for BCHP	See above					0
Develop advanced cooling technologies for BCHP	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	50,000,000
	12,250,000	13,750,000	13,750,000	11,250,000	11,250,000	62,250,000

Analysis and Design Tools	2001	2002	2003	2004	2005	Total
Develop a BCHP models library	250,000	250,000	250,000	250,000	250,000	1,250,000
Develop a simplified analysis screening tool	500,000	0	0	0	0	500,000
Develop a screening design advice tool	200,000	850,000	850,000	500,000	500,000	2,900,000
Incorporate BCHP into existing detailed analysis tools	0	0	500,000	500,000	500,000	1,500,000
Validate design and analysis by field performance	0	600,000	800,000	600,000	600,000	2,600,000
	950,000	1,700,000	2,400,000	1,850,000	1,850,000	8,750,000

Total	24,000,000	76,850,000	79,350,000	65,100,000	65,100,000	310,400,000

Technology Destination

Highway

BCHP Package Integration
BCHP today consists of discretely developed technologies of power generation, thermal cooling and dehumidification, thermal transport and storage, thermal heating and hot water systems, and electric end-use equipment. These discrete components currently can be interrelated by building control systems. It is essential to improve individual components and further integrate BCHP systems in the near term. These steps will:

- Improve performance (efficiency),
- Increase reliability,
- Reduce first (capital plus installation) cost, and
- Reduce maintenance cost.

Pathway & Partners

I G A ac

Improved packaging of components through the formation of BCHP partnerships is essential. This will bring together all elements of building mechanical equipment into logical BCHP development groups. By concentrating on actual projects available within the government and throughout industry, RD&D costs can be reduced.

Impact & Timeframe

1 1

Actual projects exist today that can simulate standard packaging partnerships and fast track BCHP in government buildings. DOE is developing a competition specifically tailored to form BCHP partnerships. An RFP is scheduled to be issued in June 2000.

BCHP packaging research and development programs will be designed for market introduction within three years.

RD&D Programs

Focus Question: What research, development, and demonstration programs will achieve the technology destination, as modified?

In order to further packaged integration of BCHP systems, work mainly needs to be done in the areas of product level integration, evaluation tools, demonstrations, and guidelines/performance criteria. Other RD&D needs include component and control system development, marketing, and training.

The most important area for RD&D is in product level demonstrations of integrated packages. Packages that include heat recovery are the most compelling. This is envisioned as component identification, integration, and optimization. Examples of key component combinations that should be part of these package demos include desiccant/generators, boiler/generators, and absorption chiller/microturbines. Integration of storage into the package is also singled out as an important need.

The need exists for other product level package integration projects, with the initial emphasis on identification of the most important package combinations. This “top-down” approach complements the “bottom-up” approach discussed above for thermal recovery systems.

The “demonstrations” category houses projects that are seen as quick turn-around, using sites where multiple components already exist, and only integration is needed. These demonstrations should be located in such public buildings as theaters, hospitals, schools, and office buildings.

Packaged integration RD&D should incorporate some component and control system development including intelligent control systems and low cost desiccants. Marketing is also considered to be of some importance, but no single project is deemed essential.

RD&D program ideas are listed in Appendix D. Important categories of RD&D activities for the next generation of packaged BCHP systems include development of benchmarks and metrics, demonstration projects, integration enablers, research, improved component technologies, applied technology, and outreach, education, and communications.

As illustrated in the table, the most important need is to demonstrate integrated, packaged BCHP systems in existing buildings, including federal government buildings, buildings owned by private sector organizations, and institutions, such as universities and hospitals. Packaged systems should be demonstrated in at least 100 federal buildings, as a signal to the private sector that the federal government is serious about BCHP. Activities that need to be included in these demonstrations are creation of “SWAT” teams to properly design, install, monitor, and maintain the systems, development of remote monitoring and diagnostic systems, central control of multiple buildings, the use of exhaust heat to drive absorption chillers, and effective customer feedback and data reporting processes.

Other demonstration projects, such as dry duct and desiccant systems to improve commercial cooling efficiencies, are included as part of the overall need for a strong technology demonstration program.

There is a need for development of benchmarks and metrics, to more effectively monitor and measure the effectiveness of packaged BCHP systems. Benchmark studies are needed to establish metrics to characterize heat recovery component performance, utility rate structures, map thermal vs. electric loads, and conduct source energy comparisons, among other study topics.

Successful demonstration projects will depend on integration “enablers”, such as communication protocol standards for integrated system controls. Building components need to “communicate” with each other, and communication systems need to be designed as “plug & play” for ease of use by building managers and monitoring staff. Control strategies and algorithms for real-time optimization of system operations will enhance the quality of data collected and the long-term reliability of packaged systems.

A number of research priorities were identified, including laboratory-based rapid prototype evaluation of integrated BCHP approaches, heat exchangers materials, sizes, and costs, sensors, advanced HVAC/power generation/storage product development, environmental and emission benefits of BCHP, and hybrid/small tonnage gas air conditioning. Basic research will provide security among BCHP designers, manufacturers installers, and building owners and managers that their financial investment in packaged systems will pay off.

Other RD&D priorities included improved component technologies, such as internal combustion engines, low NOx technologies for high efficiency reciprocating engines, and improved, low cost electrical grid interconnection switches and controls. Application of new technologies, such as internal combustion engines, reliable fuel cells, and waste heat exhaust systems for desiccants and absorption cooling, particularly in a demonstration environment, is also seen as important.

Although effective communications, outreach, and education on packaged systems is considered extremely important by participants, the Department of Energy will be sponsoring a separate workshop on this topic and thus is not discussed further in the context of RD&D programs.

RD&D Program Descriptions

Focus Question: What are the major elements of the top priority RD&D program ideas?
Five projects were identified for priority funding in the near term to improve the design and use of packaged BCHP systems, including:

- Development of a building demonstration program, for both new and existing building stock, to include 100 federal government buildings, private and public institutional buildings, and private commercial buildings
- Near-Term, High-Value Demonstrations
- Package Integration of Thermal Recovery Equipment
- Design and development of modularized BCHP packages and systems
- Design and implementation of a benchmark study to establish BCHP metrics
- Prime mover efficiency, cost, emissions, and reliability research and development
- Standardized Control Protocol (Communication) for BCHP
- Development of advanced “plug & play” controls for integration systems
- Identify Other Integrated System Concepts

Development of Building Demonstration Program

Demonstration projects for packaged, integrated BCHP systems provide effective monitoring and measurement opportunities. The purpose of this proposed project is to demonstrate packaged, integrated BCHP systems in federal, institutional, and commercial buildings, both in the public and private sectors. The approach to this effort is to define system data needs, select target buildings (100 federal government and 100 private sector buildings), install packaged BCHP systems with the use of “SWAT” teams for design, installation, monitoring, and data collection and reporting, establish remote monitoring diagnostic systems, collect data through centralized control and operation procedures, analyze the data, and obtain customer feedback from building owners and operators.

The proposed project would begin immediately and take at least five years to complete. Associated costs are estimated to be $20 million for private buildings, and at least that much, if not more, for federal buildings. These numbers are predicated on 50-50 cost sharing, between the government and building owners and managers. Two million dollars per year is estimated for monitoring, data collection, and analysis. Project deliverables include development of a CHP packaged system database, design and construction specifications resulting from design competitions for the demonstration program, development of a set of case studies based on the demonstration buildings, and development of incentives or directives for implementation of BCHP packaged systems.

This project would necessarily involve a large number of performers, including building owners and operators, building-related associations, such as BOMA, state energy offices, DOE national laboratories with expertise in buildings (ORNL, LBNL), GSA, consulting architects and engineers, building equipment manufacturers, and electric and gas utilities. Because buildings are such an integral part of our environment, and the results of building demonstrations could be helpful to many other organizations and institutions, linkages to other programs and projects would be important. For example, successful BCHP building designs resulting from the demonstrations could be utilized by ASHRAE, AIA, NAHB, BOMA, and other organizations involved in standard setting, design guidance, and training. Government agencies involved in new construction or retrofits, such as GSA, DOD, and HUD would be able to take demonstration project results and utilize them for design and construction of BCHP systems in federal buildings. Other linkages to state governments, particularly those who are in the forefront of energy-conscious design strategies, such as Wisconsin, New York, and California, and universities would improve the likelihood that BCHP systems would be installed in commercial and institutional buildings.

Near-Term, High-Value Demonstrations

This is a "quick turn-around" project. Existing systems are identified. A system must consist of two or more components that are currently not integrated in an optimal manner. A number of high-value sites (about 10) including schools, office buildings, hospitals, etc. are chosen. The systems are installed in the high value sites, and data is collected. These demonstrations should be up and running within a year of a 2001 start-up date. (Projects funded independently of DOE could be running earlier). Up to $1 million per site would be budgeted for this project.

Data gathered in this project would be provided as a design guide for Project 1. This project would also serve as a test bed for Project 2 software. Participants in this project would include local utilities and equipment manufacturers as well as site owners.

Packaged Integration of Thermal Recovery Equipment

This project, as previously mentioned, should incorporate a "bottom-up" approach of choosing appropriate component combinations and identifying sites where they could be integrated and demonstrated. In order to maximize results, several contractors should receive awards (perhaps 3-6) each using a different prime mover (e.g., fuel cell, microturbine, IC generator set, etc.). These should be combined with components such as chillers, absorbers, or boilers, with or without storage incorporation. The design and development of interface and building energy management controls are also part of this project.

Depending on the number of contracts awarded, this project should cost $30-50 million, and should be accomplished in 2-3 years, starting in 2001. The project should be industry led, but should also include government, academia, and where appropriate, trade associations. The project must utilize evaluation tools to assess components, and also must link to control protocol tasks. Shorter duration demonstrations (From Project 4) will provide qualification of design tools for this project. Analysis tools will help to determine the next step.

Design and Develop Modular BCHP Packages and Systems

The purpose of this project is to design, build, and test building cooling, heating, and power components and systems so that they may be easily and cost-effectively installed in public and private buildings, by a wide range of building professionals, without the need to custom-design each system for each individual building. By designing a modular, integrated system, it is hoped that both the cost and ease of use of such integrated, packaged systems will improve.

The project would be conducted over a 3-year time period, at a cost of $2 million for design, and $10 million for construction, implementation, monitoring, analysis, and reporting of a prototype modular BCHP system.

Among the tasks to be completed for this project would be the complete design of a BCHP system in a chosen building, installation of such a system, design and testing of adaptive components, design and testing of the heat exchanger, air quality sensors, and other elements of the system, and development of performance criteria.

At its conclusion, this project would result in 4-6 BCHP packages with consistent evaluation criteria, which could be installed in public and private buildings of varying types, styles, and uses.

Performers for this project would include energy service companies, which have a vested interest in seeing successful BCHP systems designed and installed, joint ventures composed of design teams and partnerships, manufacturers of individual heating, cooling, and ventilation equipment components and systems, and architectural and engineering firms.

Linkages to other programs, organizations, and institutions would improve the likelihood that modular BCHP systems would be installed. Thus, linkages to RD&D of advanced “plug and play” controls, as well as linkages to the results of the proposed demonstration-building project, would be effective in implementing modular system designs.

Design and Implementation of a Benchmark Study to Establish BCHP Metrics

This project involves development of a benchmark study to establish building metrics for building cooling, heating and power systems. It is conceived as a one-year effort, at a cost of $500,000.

A number of tasks are envisioned, including creation of a BCHP installation database; development of “best practices” vs “typical application” scenarios; definition of life cycle cost analyses; characterization of heat recovery component performance; establishment of target buildings; establishment of reliability factors for grid vs. existing self-generated technologies; development of source energy comparisons; mapping of thermal vs. electric loads; analysis of utility rate structures; development and maintenance of a compatible component database; and definition, measurement, and evaluation of indoor air quality in selected buildings.

The primary deliverable is a set of reports and databases that are reflective of the tasks outlined above.

Performers include consulting firms (architects, engineers), component and system manufacturers, universities, ESCOs, and service providers. Linkages to the Energy Information Administration, Census, International Energy Agency and the CHPA of the UK, associations such as GRI, EPRI, ARI, AGA, etc., and the Federal Energy Management Program are important for information and data sharing, since all of these organizations collect and dispense buildings data and information. Their CHP experiences and building expertise both add to, and are assisted by, development of good-quality metrics for packaged BCHP systems.

Prime Mover Efficiency, Cost, Emissions and Reliability Research and Development

This project involves the conduct of basic R&D on prime mover components, such as fuel cells, IC engines, chillers, boilers, microturbines, and other equipment that drives building heating, cooling, and power systems. The project is conceived as a five-year effort, at a cost of $200 million, cost-shared on a 50-50 matching basis.

The tasks to be conducted include research in the following areas:

Process and cost reduction related to high-temperature materials
Reduction technology for NOx, e.g., catalysis R&D
Research and analysis on materials costs, life cycle costs, etc.
Fuel cell R&D
Improved availability, reliability, and durability of component technologies
Conduct of “trade-off” studies (cost, reliability, etc.)
Design, build, and testing of prototype components

Deliverables include construction, testing, and monitoring of breadboard units, publication of field test results, and development of prototype packages.

Performers are expected to include universities, equipment manufacturers, national laboratories, private sector laboratories, contract research and development organizations, and material suppliers.

Linkages to other programs within DOE, include within the Office of Industrial Technologies, the Office of Transportation Technologies, and Fossil Energy, as well as to the National Laboratories, including Sandia, LBNL, Lawrence Livermore, and ORNL, and to other projects, such as analysis and design tools, provide technology transfer to demonstration and commercialization efforts underway in these organizations.

Standardized Control Protocol (Communication) for BCHP

It is recommended that this $5 million project start in 2001, and run for 2-3 years. The DOE request would be for the identification of a control protocol for U.S. Government buildings. It would include investigating what current protocols are being used (if any) and the selection of the most applicable. An appropriate linkage would be to Project 1, where results from the demonstrations could determine what the control protocols need to say. With proper control protocols in place, the onus for meeting their demands by modification of existing equipment will fall upon industry. It is envisioned that the project could be headed by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), and would include input from control companies.

Development of Advanced "Plug and Play" Controls for Integrated Systems

This project involves development of "plug and play" controls that can be cost-effectively installed in buildings. The project is estimated to be completed in three years at a cost of $4 million. Tasks include:

- Development of protocol communications standards for integrated system controls
- Development of smart, supervisory control systems
- Development of advanced on-board diagnostics
- Definition of information to be transferred between equipment components
- Identification of inputs/outputs for each component
- Conduct of a summit for existing standards organizations

Deliverables include a protocol definition document, and demonstrations of "plug and play" controls and supervisory controllers.

Performance for this project includes equipment and control manufacturers, university research institutes, and industry associations. Linkages are expected with international standard setting organizations (ISO), organizations involved with the Fuel Cell Summit, the Modular BCHP Package/System project and the Buildings Demonstration project developed by this Breakout Session group. In addition, linkages to other technologies in other end use sectors, such as the SAE (Society for Automotive Engineers) Standard for Engines (J1939), may be helpful.

Identify Other Integrated System Concepts

This project is the longer-term analog to Project 1. It provides the top-down approach of identifying integrated systems that are needed, but do not exist. The project would include a market study and needs assessment, and would identify new technology requirements. A rate structure analysis, a payback period study, and an assessment of efficiency would be part of the analytical approach. It would be industry-led, but would include government laboratory and university components.

The budget is estimated at $30-50 million, but the 3-year project would not get started until about 2003. Examples of components that would be optimized in such a project include low-cost, low temperature desiccants and absorption systems as well as exhaust heat exchangers.

Technology Destination

Highway

Next Generation of BCHP Systems

The BCHP system of the future will be able to operate in a variety of modes using modular system packages that can be customized to meet the individual needs of a wide variety of users. BCHP systems will achieve “flexible interdependence” with electric and gas utilities. This means BCHP systems will be able to provide users with the benefits of both interconnected and grid-independent operations, depending on the specific needs of the user. As a result, BCHP systems will be able to operate efficiently and effectively in many different types, sizes, and groups of buildings. This will provide building owners and operators with reliable energy supplies, a range of energy choices, high efficiency and low emissions, healthful indoor air quality, and financially attractive returns on investments. The outcome will be greater global sustainability in the built environment.

Pathway & Partners

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The ultimate goals are very ambitious and require advanced component development, packaging and integration research.

DOE, Industry and Academia will come together, through BCHP technology workgroups, and develop key design strategies and program plans in the fall of 1999.

Impact & Timeframe

1 2

Achieving the 2020 Vision requires introduction of new GRID Independent BCHP Systems by 2010.

RD&D Programs

Focus Question: What research, development, and demonstration programs will achieve the technology destination, as modified?

The RD&D program ideas are listed in Table 5.2. Important categories of RD&D activities for the next generation of BCHP systems include new design strategies, communications and control systems, and advanced BCHP equipment. Supporting activities are also needed in analysis, policy development, and business development.

There are extensive needs for information and education on the costs and benefits of BCHP systems and these should be addressed as part of the RD&D program aimed toward next generation BCHP systems. For example, there is an immediate need to document and disseminate information on existing BCHP success stories. Potential users need to be made aware of the energy, environmental, and economic advantages of BCHP. Without extensive education, market demand for next generation systems may not be very strong. There is also a need to reach architects and building designers with information on BCHP technologies to accelerate the pace at which new building optimization strategies can be developed and used.

In new equipment, there is a need for advanced power generation, cooling, heating, ventilation, and energy storage systems. Power generation system costs need to be reduced, emissions need to be lowered, and renewable fuels and technologies need to be used. Advanced cooling cycles need to be developed and incorporated into BCHP system designs. Lower cost and more efficient thermal distribution is an important RD&D target. Lower cost and higher performance ventilation and dehumidification systems need to be developed. Lower cost electric, chemical, and thermal storage systems are needed for use in buildings. And, advanced systems need to be designed for a plug & play marketplace, which will mean greater standardization and more modular and packaged systems. The "hassle factor" associated with existing systems will need to be eliminated.

Communications and control systems will be needed to achieve "flexible interdependence" with the electricity and natural gas grids, and among building operations for district energy and other forms of load aggregation. Monitoring technologies will need to include artificial intelligence to enable automated operations and remote diagnostics. The communications and controls infrastructure will need to be designed to enable real-time exchanges of operational information within a BCHP facility, among multiple BCHP participants, and between BCHP users and their electricity and natural gas suppliers.

RD&D Program Descriptions

Focus Question: What are the major elements of the top priority RD&D program ideas?

Among the top priority RD&D program ideas were the following actions:

Case studies (detailed) of success stories
Create a BCHP and building design clearinghouse
Develop BCHP monitoring software and systems
Develop plug & play systems and equipment for BCHP
Develop advanced cooling technologies for BCHP applications

Monitor Case Studies of Demonstrated Success Stories

The purpose of this proposed project is to demonstrate the advantages of BCHP systems to a wider number of building owners, operators, and other potential users. The approach is to collect information on the monitored performance of BCHP systems, document existing and emerging applications, and publish information in the form of case studies using all available communications channels. The proposed project consists of two phases. The proposed project calls for the initial phase to begin as soon as possible, focus on existing sites, last for 2-3 years, and cost approximately $5 million. The second phase would also start as soon as possible, would extend 3-5 years beyond the initial phase, would focus on the dissemination and replication of success stories from the initial phase, and would cost an additional $5 million.

The initial phase would begin with the development of an analysis framework and monitoring protocols for the case study analysis. The framework would provide a rationale for selecting up to 20 case study sites in the initial phase. This sample of 20 would be selected to cover a representative group of building types, sizes, BCHP equipment, and climate conditions. Once selected, instrumentation and monitoring equipment would be installed on those sites lacking comprehensive information on key metrics such as energy efficiency, emissions, indoor air quality, reliability impacts, and economics. Existing information and data records from the site operators would be used to the maximum extent possible. Information would be compiled and analyzed for each of the 20 case study locations. Reports would be prepared for each case study.

The second phase would begin immediately to begin the process of establishing partnerships with organizations for the replication of the success stories in new sites beyond the initial 20. This would include discussions with decision makers in various national and state agencies and non-governmental organizations. The goal would be to leverage federal resources to increase the number and coverage of new case study opportunities. A national strategy would be developed for increasing the number of case studies to include existing and new sites based on a collaborative process with national, state, and local organizations, trade groups, and professional societies.

The second phase also involves an extensive technology transfer effort using workshops, conferences, publications, and the World Wide Web. “Lessons learned” information would be published on BCHP designs, systems, and strategies.

There would necessarily be a large number of performers and participants in this program. A peer review panel would be established to ensure quality control in the analysis framework and in the consistency of the information and reporting. Existing research organizations such as AIA, ARI, ASHRAE, IEEE, and others would be involved. Universities and the national labs would be involved in the collection of information and documentation. Key participants will be the building owners, operators, designers, and financiers at the case study locations. Also involved will be the equipment manufacturers and representatives from the relevant state and local regulatory agencies.

This program has important linkages to other RD&D actions. For example, software and analytical tools to develop building and BCHP performance models could use information from the monitored case studies to validate data and algorithms. Development of building design optimization strategies for BCHP systems could also benefit from data from the case studies. Development of monitoring systems and technologies and advanced BCHP equipment could also benefit from the case studies.

Create BCHP and Building Design Clearinghouse

The purpose of this proposed project is to provide the building and equipment design community with an information resource dedicated to BCHP development. The approach is to gather existing information and make it available to a large number of potential users. This proposed project would be started as soon as possible and would continue for the duration of the BCHP program. The annual cost would be approximately $500,000.

The project would begin with the development of a business plan for the clearinghouse. This would involve reviewing the specifications of existing information resources for building and equipment designers and conducting bench marking studies to determine best practices. These efforts would result in a mission, a suite of products and services, and funding requirements. The next step would be to collect existing information on building, equipment, and BCHP design tools and related information from a variety of sources including professional societies, project developers, and national laboratories. At the same time a communications strategy would be developed to determine the types of media to be used. The Clearinghouse is likely to be a web-based concept, but will also involve publications and conferences. One of the possible services will involve hiring experts to answer questions from design practitioners in the field. To achieve the highest possible levels of quality control, information resources will undergo extensive peer review.

The developers and operators of the Clearinghouse will need a variety of capabilities in building design, BCHP technologies, and communications strategies. A consortium of university(s), national laboratories, and state agencies could be tapped to ensure “product and supplier neutrality” in implementation.

This proposed project will benefit from information products from the case study project mentioned above. Information on new optimization strategies, new BCHP equipment, and new buildings and BCHP monitoring systems and equipment could be provided to users through the Clearinghouse.

Develop BCHP Monitoring Software and Systems

The purpose of this proposed project is to develop advanced monitoring software and systems to enable greater automation, remote diagnostics, and “continuous commissioning” for maintenance and servicing of BCHP systems. This proposed project would begin after the development of the analysis framework and monitoring protocol for BCHP systems discussed under the proposed case studies project outlined above. This proposed project would have a 2-3 year duration after which time further development work would be undertaken by industry. The estimated budget for this project is $1-2 million with an equivalent amount provided by industrial cost sharing.

The first task would be to determine the types of BCHP systems, subsystems, and components to monitor and the metrics to be used for tracking performance. This task would involve extensive reviews of existing monitoring systems for buildings and building equipment. The next steps would involve development of algorithms for detecting operational problems and user-friendly interfaces for communicating problems to servicing and maintenance personnel. Systems to track problem solving and remote diagnostics for feedback would also be developed. The monitoring software and systems would include impact studies to track equipment performance, time between failures, and costs to repair.

To design and develop proper monitoring software and systems for BCHP a number of key participants and performers will need to be involved. Universities and national laboratories have the requisite expertise to conduct the initial tasks with the goal of transferring technologies to companies in the business of building and equipment monitoring and controls. Building and equipment maintenance firms would be consulted in the design stages and building site owners and operators would be engaged for system testing, verification, and validation.

Outputs from this proposed project will be useful to other programs, projects, and tasks in BCHP. For example, monitoring systems can be used in the design of next generation BCHP equipment to enable plug & play applications. BCHP monitoring systems can also be used to verify and validate provisions of performance contracts, and in the design of optimization strategies.

Develop Plug & Play Systems and Equipment for BCHP

The purpose of this proposed project is to begin the RD&D process on the next generation BCHP system that will have standardized components, modular design to “mix & match” systems and subsystems, and involve “hassle-free” operations. The approach involves conducting research to develop system definitions, specifications, and requirements for plug & play applications and then transfer the technology to industry for further development and commercialization. The proposed project can start as soon as possible and would be a 3-year effort with total funding of approximately $3 million. There would be a competitive solicitation to award contracts to companies and teams of companies. Cost sharing would be part of the solicitation process.

The first steps would involve development of definitions, standards, and specifications for plug & play BCHP systems. These will vary by BCHP size, configuration, and building type. Analysis will have to be done to determine sizing and scalability for BCHP by building type, equipment type, climate zone, and building function. An effort would be needed to develop operating and control systems for BCHP equipment, including communications protocols for the exchange of information with equipment suppliers, local electric and gas utilities, and energy services companies.

The competitive solicitation would seek applicants and teams of applications for the activities discussed above. It is expected that manufacturers, designers, users, and systems integrators would be involved alone or in teams in accomplishing proposed tasks. National laboratories and universities would be encouraged to participate as parts of the industrial teams.

Linkages to other RD&D programs and projects include the use of BCHP monitoring and control systems and equipment, use of optimization strategies, and specifications for smaller, quieter, and easier to package power, heating, cooling, and ventilation equipment for BCHP.

Develop Advanced Cooling Technologies for BCHP Applications

The purpose of this proposed project is to begin a multi-year RD&D process to develop advanced cooling technologies specifically for next generation BCHP applications. The approach is to refocus existing and launch new RD&D initiatives in the broad area of advanced cooling systems. The proposed effort would start as soon and possible and continue for at least five years. The effort would encompass government and industrial research programs. The estimated funding requirements over five years would be approximately $50 million from the federal government and an equivalent amount in cost sharing from private industry.

The scope of the proposed program would include all types of cooling systems that can be fully integrated in BCHP applications. Effort would be undertaken to develop advanced absorption cooling, desiccants, engine-driven chillers, thermal recovery, thermal energy storage, and compact enthalpy and desiccant wheels. Research and testing would be conducted to ensure system reliability and durability. Targets would be established for efficiency, costs, durability, maintenance, and environmental emissions.

The program would involve a number of RD&D performers including the national laboratories, universities, and equipment manufacturers. Strengthening linkages with on-going related efforts at the Gas Research Institute, American Gas Cooling Center, International Energy Agency, and industrial laboratories and research organizations would be a top priority.

The advanced cooling technologies that are produced by this program will be designed for plug & play BCHP applications and incorporate appropriate monitoring and diagnostic systems. Field tests and demonstrations would be candidates for case studies. Efforts would involve extensive coordination with the development of advanced power generation, heating, ventilation, and energy storage systems.

Technology Destination

Highway

Analysis and Design Tools

Owners, consulting engineers and manufactures/utility/ESCO sales representatives need accurate and useable BCHP software tools to facilitate implementation of existing and new integrated systems. It is anticipated that several tools ranging from screening to detailed design and analysis will be needed to meet the requirements of various groups of users.

Pathway & Partners

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DOE is the catalyst that can bring together individual industry partners led through an expert advisory team. This team can oversee projects bringing together other partners: tool developers, national laboratories, academia, consulting engineers, sales representatives, marketers, and ESCOs. Projects will include non-proprietary models and algorithms, educational programs, databases (such as BCHP model and utilities rate) and software tools.

Impact & Timeframe

1 1

Well-packaged methods of selection and economic justification will facilitate BCHP implementation. In the short term, existing tools will be enhanced to include BCHP. In the long term, more rigorous and validated BCHP models will be developed.

RD&D Programs

Focus Question: What research, development and demonstration programs will achieve the technology destination, as modified?

RD&D program ideas related to BCHP analysis and design tools are listed in Appendix D. Important categories of RD&D activities for this area within buildings cooling, heating, and power include software development, software validation, and the production of necessary building block libraries and protocols that will encourage BCHP system installation. Also, there are needs for application, case study, and educational tool development in the analysis and design tool area.

Not surprisingly, there is a large need for the development of several different software tools such as screening, design, and advice tools. These tools should be fast, highly graphic, and user friendly. In the very near-term, a simple screening tool should be developed that incorporates BCHP into an existing tool. In the long term, unique detailed BCHP tools should be developed that may be used for both screening and design needs.

Once analysis and design tools are developed, they need to be validated against real on-line systems. This validation process should precede the creation of validation standards and measurement protocols for the software tools developed.

Two different types of fundamental activities need to expand in order to further the development and use of analysis and design tools. First, libraries need to be created that include mathematical descriptions of primary and secondary equipment as well as equipment performance. Also, databases should be developed that contain utility rate information and thermal load profiles. Finally, there is a need to accomplish specific building-block action items that will provide a basis for screening tool design and development. These include the development of standard elements for manufacturer data, such as design procedures, as well as the creation of a strict set of screening tool rules.

Although indirectly related to analysis and design tools, another high priority activity falls under the category of education. There is a need for the development of a training program for end-users and educational tools for designers. Building-block libraries can and should be incorporated into this process.

Finally, other high-priority programs for analysis and design tools are related to applications. There is a growing need to generate BCHP system templates for common software tools. Additionally, there is a need to develop BCHP application case studies. These case studies could be documented on compact disks or videos and would be useful tools to promote BCHP systems in the market arena.

RD&D Program Descriptions

Focus Question: What are the major elements of the top priority RD&D program ideas?

In order to ensure the systematic completion and implementation of all tools and building blocks, a team of professionals should be selected to serve on an expert advisory team to oversee all analysis and design projects. This team should be comprised of key members of the BCHP community as identified in the revised analysis and design pathway and partners destination statement. This team should be involved throughout project procurement and development. Not only should the advisory team oversee individual projects, but they should also monitor the larger picture to insure that design and analysis tools will meet future needs and requirements. RD&D program and project elements in the area of Analysis and Design Tools are displayed in Appendix D.

Development of a BCHP Models Library

Development of a Simplified Analysis Screening Tool
Development of a Design Advice Tool
Incorporation of BCHP into Existing Detailed Screening Tools
Validation of Analysis & Design Tools by Field Performance

Development of a BCHP Models Library

This project involves the creation of a comprehensive electronic library that consists of detailed descriptions of primary and secondary equipment models. The library should contain equipment performance and specifications on 12-25 different pieces of equipment. There is a need for this tool to be non-proprietary and contain input and output relationships. The project should begin as soon as possible and should last approximately five years. Development of this library has an estimated cost of $1-2 million to complete three separate tasks.

The first task is the completion of a survey to ascertain what types of equipment models currently exist and what needs to be developed in order to "plug the holes." This initial survey could be a two-month task, which directly leads into the next task, which is to develop the missing models for the library. This second task should last six months to a year and would lead to the development of an initial simple library. The final task, lasting two to five years, would be to develop more detailed and comprehensive equipment models for the library.

The development of a BCHP models library is linked to several other projects including design and analysis validation and development of an algorithms library. Most importantly, this project will help provide additional and updated information for existing BCHP equipment models.

Development of a Simplified Analysis Screening Tool & Development of a Detailed Design Advice Tool

It is important to have analysis and design tools for users to utilize to determine the most economical BCHP system for a building, given specific load requirements and other input factors. As a result, a fast, graphically advanced analysis-screening tool will be developed for this project. This project is split into two different phases. Phase one involves creating an initial "simple" tool that would provide economic answers to installing specific BCHP equipment. This simple tool would also provide operating strategies, equipment configurations, and continuous feedback to the user. Phase one would cost $500,000 and last for two years.

Phase two is on a long-term scale and consists of developing a detailed design advice tool that would be fused with the simple screening tool. In addition to the user requirements established in the initial phase, this additional element would include an educational component that provides "rules of thumb" for BCHP systems. Phase two would cost at least $1,000,000 for three additional years after completion of phase one. There are different tasks associated with each of the phases.

Phase one would consist of creating a user interface program for the tool while utilizing other simple pre-existing tools by adding to engines and front ends. Once the tool is completed and implemented, it should be tested, validated, and then surveyed for user feedback.

Phase two begins after the completion of phase one and consists of creating an advisory web page in the first two to six months. Following the completion of this task, a year would be devoted to adding building type and load profiles into the tool. At the end of the fifth year of the entire project, the tool should include information on real-time expert systems. Although the project is targeted to be completed at this time, continuous upgrades would be made to the tool such as adding in new equipment, changing output algorithms to be more accurate, and adding additional details.

The necessary partners for both phases of this project are DOE (to provide the website/platform for the tool to be used), existing tool developers, marketers, sales representatives, ESCOs, consultants, and an unbiased and objective manager of the tool. This initial screening tool development phase would be associated with projects such as developing BCHP templates, providing quick model consensus, and developing a models library. Finally, this project will occur in tandem with the incorporation of BCHP into existing tools to create a complex software tool.

Incorporation of BCHP into Existing Detailed Tools

This project feeds directly into the development of the simple screening tool. This more complex tool would be developed further down the road and would be more accurate, comprehensive, and extensible than the simple screening tool. This tool would give quick output responses of specific equipment designs and provide economic answers to BCHP questions in a user-friendly manner. In addition, the detailed analysis tool should be validated against real-time operating BCHP systems. It is projected that this project will cost $1-5 million and would take five years to complete.

Initially, an advisory web page that would be part of the BCHP program's home page would be designed. This web page would utilize the simple screening tool as a basis. Next, building and load profile types will be added and other additions will be incorporated to make this a highly advanced BCHP analysis tool. Finally, continuous upgrades such as beta testing and user feedback would be added to the tool to keep it up-to-date and useful for future users.

Validation of Analysis and Design Tools by Field Performance

All BCHP design and analysis tools developed should undergo a system-level validation. This will provide user confidence of both the actual BCHP systems and of the design and analysis tools. It is estimated that the validation process will cost $300,000 per project. This figure includes instrumentation but not equipment costs. Each analysis and design tool validation should last approximately a year with the limiting factor being identifying and utilizing actual BCHP equipment.

The tasks in this project follow basic scientific methodology. First, it is necessary to decide which systems need to be validated and then to conduct a survey of these existing BCHP systems. Once the survey is completed, installations are selected. Some possible factors on which to base installations are: age of equipment, cost of validation, and ease of data collection. Once installations are chosen, a standardized experimental design is developed and the validation process is begun. Once real-time data is collected, analysis and design tools are used to simulate the system and the two data sets are compared. It is essential that any data discrepancies are resolved so that simulated data is consistent with real-time data. All real and simulated data should be stored in a database, which is updated as different BCHP system validations are completed.

Market Implementation Destination
2/00 (Rev 6)

The emerging BCHP industry considers the changes resulting from electric utility restructuring as the most significant issue affecting mechanical systems in buildings.

Commercial and Institutional buildings exhibit poor load factors dominated by space cooling and characterized by wide variations in daily loads associated with occupancy patterns. The building sector has unique application-specific requirements relative to occupancy-based cooling loads and heat utilization. The thermal-to-electric demand ratio, operating flexibility (cycling and part load operation), and diversity of building size and function may require significant modification/adaptation of onsite/near-site generation and CHP technologies developed for industrial application.

Energy, IAQ and environmental issues will be the most dominant factors in the building industry in the coming years. New players will emerge to generate and/or market energy, providing a wide variety of price, quality and reliability of supply. As the retail energy market emerges, providing energy and energy services to buildings, the economics of mechanical and power systems will dramatically change.

It appears likely that the tradeoff in electric pricing (driving off-peak prices further down and on-peak prices very high) will occur because of an extremely competitive base load marketplace and the need for profitability, while also supplying peak-load capability. It is here that BCHP systems will likely grow and flourish provided they satisfy the other key drivers.

However, there is a major disjuncture between the emerging economic realities of electric restructuring, electric grid reliability issues, environmental concerns and pressing indoor air quality issues and market acceptance of BCHP approaches. This disjuncture can be attributed to lack of understanding and certainty among the general public, policy makers, HVAC professionals, building owners, and the construction trades concerning likely outcomes that electric restructuring, the environment and IAQ will have on their business. This lack of understanding is true when examining each issue and magnified when looking at the convergence of these major issues (electricity costs, future grid reliability, energy efficiency, Greenhouse Gas emissions and indoor air quality “IAQ”). National leadership will shine light on the magnitude of the problems and their solutions. The BCHP Initiative will need to provide information and tools to policymakers and throughout the channels of distribution.

Forty-two technical experts, representing government, national laboratories, manufacturers, industry trade associations, consultants, research and development organizations, utility companies, ESCOs, engineers and architects, and academia worked together to develop specific project proposals for BCHP systems. The workshop was sponsored by the U.S. Department of Energy, coordinated by Exergy Partners Corporation, and facilitated by Energetics, Incorporated.

Three focus questions were asked of participants, who were divided into four groups. The four groups were:

Marketing and Sales
Design and Installation
Operations
Maintenance

The three focus questions were:

1. What is the key “descriptors” of the BCHP process [marketing, installation, operations, and maintenance] in 2020 for the BCHP vision and roadmap to be achieved?
2. What are the key actions that need to be undertaken to advance BCHP [marketing, installation, operations, and maintenance] to achieve the destination, goals, and vision of the BCHP roadmap process?
3. For the most important actions, what needs to be done, by when, and by whom to achieve the destination?

Crosscutting Issues and Themes

To achieve the 2020 Vision for Building Cooling, Heating and Power, with its emphasis on global competitiveness, energy efficiency, market opportunities, and technology development, a new “paradigm” must be established for heating and cooling buildings in this country. Building owners and operators, designers and contractors, and most importantly, end-users, must become educated on the benefits and costs of BCHP. Each of the four Breakout Session reports at this Process Workshop addressed the following issues:

- The need for understanding and acceptance of BCHP terminology, life cycle costs and benefits, and risk associated with this way of heating and cooling buildings
- The development of standardized equipment methodologies to minimize application engineering and non-recurring costs, so that BCHP systems may be integrated into traditional building energy management systems and the grid
- The need for state-of-the-art information and telecommunications technologies for remote automation and control of BCHP functions, so that BCHP systems are perceived as simple
- The need for continuing education and certification of technicians, operators and owners of BCHP systems and an established network of installation, operations, and maintenance providers.

Recognizing that these issues are important to the future of BCHP, a number of crosscutting project ideas resulted from the Breakout Sessions.

The market for BCHP systems needs to be more clearly identified, understood, and promoted. The sales and delivery chain is key to marketing, installing, operating, and maintaining these systems. Market opportunities abound for BCHP; the challenge is pushing or pulling the market to see BCHP as the cost-effective choice, when other, traditional building HVAC choices are better known and easily designed.

Demonstration projects of successful BCHP components and systems are key to illustrating the cost and energy improvements resulting from installation, operation, and maintenance of BCHP systems. In all areas – marketing and sales, installation, operations, and maintenance – demonstrations provide real-world information.

All four breakout groups similarly recommended development of strong alliances among government, industry, and trade associations, to bridge common concerns and address end user perspectives on building cooling, heating and power. Such alliances would help to break down resistance to BCHP technologies and enhance educational and outreach activities.

And finally, all participants at this workshop recommended that a key to moving BCHP forward is making more effective use of existing delivery channels for building design, construction, operations and maintenance. The design and construction of buildings is an established process. BCHP provides an opportunity to save and produce energy at a competitive price and with positive environmental impacts. Building with BCHP must become an established process, and a standard, accepted concept within the design and build professions.

Market Workshop Programs and Funding Recommendations

The following table summarizes the cumulative program funding recommendations of the Market Workshop participants. Note the program dollars listed would be matched by industry investment. (Note some duplication with Technology Destination in the area of demonstrations).

Marketing and Sales	2001	2002	2003	2004	2005	Total
BCHP Portfolio	500,000	250,000	0	0	0	750,000
Quantify and Document Benefits of BCHP	1,000,000	1,000,000	500,000	0	0	2,500,000
Identify and Develop Markets for BCHP	1,000,000	700,000	0	0	0	1,700,000
Develop Industry Alliances With Customers	400,000	300,000	300,000	0	0	1,000,000
Promote BCHP	500,000	2,000,000	2,000,000	500,000	0	5,000,000
Educate Policy Makers on the Benefits of BCHP	500,000	2,000,000	2,000,000	500,000	0	5,000,000
	3,900,000	6,250,000	4,800,000	1,000,000	0	15,950,000

Installation	2001	2002	2003	2004	2005	Total
Develop BCHP Engineering Methodologies	2,000,000	1,250,000	500,000	500,000	500,000	4,750,000
Develop and Conduct BCHP Curriculum/Certification for Technicians	1,000,000	2,500,000	500,000	500,000	500,000	5,000,000
Identify and Remove BCHP Installation Barriers	1750000	1,500,000	1,000,000	3,250,000	5,250,000	12,750,000
BCHP Installation Case Studies	1,000,000	4,000,000	6,000,000	8,000,000	10,000,000	29,000,000
	5,750,000	9,250,000	8,000,000	12,250,000	16,250,000	51,500,000

Operation	2001	2002	2003	2004	2005	Total
Develop 1st generation optimal operating strategies with simple human interfaces	10,000,000	10,000,000	0	0	0	20,000,000
Provide real-time measurements for different BCHP technologies	2,000,000	10,000,000	10,000,000	0	0	22,000,000
Establish mechanisms to integrate BCHP with energy markets	1,000,000	2,000,000	2,000,000	0	0	5,000,000
Conduct BCHP demonstrations to verify economics and performance	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000
Educate key participants	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	5,000,000
	24,000,000	33,000,000	23,000,000	11,000,000	11,000,000	102,000,000

Maintenance	2001	2002	2003	2004	2005	Total
Educate Technicians	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	5,000,000
Develop a BCHP Certification Program	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	5,000,000
Develop a Protocol for BCHP Controls	1,000,000	1,000,000	1,000,000	100,000	100,000	3,200,000
Educate Design Engineers and Product and Service Providers	1,000,000	1,000,000	1,000,000	0	0	3,000,000
Develop Economic Incentives	200,000	200,000	200,000	0	0	600,000
	24,000,000	33,000,000	23,000,000	11,000,000	11,000,000	
	4,200,000	4,200,000	4,200,000	2,100, 00	2,100,000	16,800,000

Total	33,950,000	46,450,000	35,200,000	25,350,000	29,350,000	170,300,000

Market Destination

Highway

Marketing and Sales

There is a distinct lack of awareness among the general public, building owners and the distribution channel for the need to improve building energy efficiency and thereby conserve natural resources, improve electric grid reliability and reduce Greenhouse Gas emissions. There is also little awareness among the general public, building owners and the distribution channel that BCHP is a viable solution to improve building energy efficiency and thereby conserve natural resources, enhance grid reliability and reduce Greenhouse Gas emissions.

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Identify & develop marketing strategies that target niche markets for BCHP
Create industry partnerships to further viability of BCHP systems in retrofit and new applications;
Develop government initiatives that illustrate leadership and provide funding sources for demonstration BCHP systems;
Design & implement promotional activities that create interest and excitement for BCHP systems among building owners and managers; and
Develop education & awareness programs that raise the level of understanding of BCHP as it compares to traditional HVAC/Power installations and provide a conducive environment for BCHP in the design community.

Impact & Timeframe

1 1

Beginning the knowledge transfer process will have a lasting impact on the rate of BCHP adoption.

This process should begin as soon as possible. Using the Internet. www.BCHP.org has be established.

ABST-2000 Conference and Exposition is scheduled to debut June 6-8 in Washington, DC.

BCHP Marketing and Sales Breakout

This breakout session identified activities that will raise awareness of BCHP products and services among trade allies, government officials, and customers. Marketing mechanisms include mass and targeted sales campaigns using current information and telecommunications technologies and services. The outcome of this set of activities is to increase sales of BCHP components and systems throughout all market segments, including residential, commercial, industrial, and institutional buildings. As customers become more sophisticated, and utility markets are deregulated, BCHP marketing and sales techniques will, of necessity, become more sophisticated. BCHP systems will eventually "sell themselves" but until then, the challenge is to show the compelling benefits of BCHP in the marketplace.

Marketing and Sales Issues for Building Cooling, Heating and Power

Focus Question: What are the key "descriptors" for the marketing and sales of BCHP systems in 2020 for the vision and roadmap to be achieved?

In order for BCHP components and systems to capture and maintain a substantial part of the HVAC marketplace, BCHP technologies will need to be understood and accepted by designers, contractors, purchasing departments, architects, engineers, and maintenance staffs. Language terminology (e.g., integration, recovered energy, indoor air quality, etc.) will need to be consistent across the building design, construction, and maintenance disciplines and accepted in the marketplace. Life cycle costs and benefits, based on accepted metrics, will need to be commonly identified and calculated, so that BCHP systems are compared evenly with traditional HVAC systems.

Purchase risk will have to be reduced, as will the ***perception*** of risk in the design, construction, and purchasing communities. Building owners and their financial advisors will have to be confident that BCHP components and systems offer the best opportunity to heat and cool their facilities at the lowest possible cost, while at the same time provide a consistent, reliable source of power. At the same time, since building owners and managers and their staffs do not see themselves in the power production and marketing business, they must have confidence in BCHP as a power source that will allow them to conduct their business, whatever it is, in a productive manner. BCHP must be seen, then, as a means to an end, not as an end in itself.

This will require education, training, and outreach to the design and construction community, as well as to building owners and managers. Targeted educational materials will need to be developed on the benefits of BCHP in terms of energy inputs, capital financing, emissions, energy efficiency, and reliability.

Breakout session participants used key descriptors (see table on next page) to develop the marketing and sales destination statement below:

> ***In the year 2020, advanced BCHP technologies are widely understood in the marketplace with metrics and tools that assist the market with cost/benefit analyses. BCHP's return on investment is recognized and accepted. Government is a major customer for BCHP systems.***
>
> ***BCHP offers building owners and designers an innovative and proven solution for obtaining reliable energy at a reasonable price while protecting the environment. Occupant productivity is increased through improved health, comfort, and environmental management.***

The characteristics/benefits of BCHP are described in educational materials and courses. Additional educational tools such as live and taped demonstrations and software are available, which measure and demonstrate reliability, monitoring, codes and standards, energy savings, etc.

Key Descriptors of BCHP Marketing and Sales in 2020

- Advanced BCHP technologies are widely understood across the market with metrics and tools that assist the market with cost/benefit assessment (life cycle)
- BCHP offers building owners and designers an innovative and proven solution for obtaining reliable energy at a reasonable cost while protecting the environment
- BCHP is understood in terms of language terminology (humidity, VOC, indoor air quality, reliability, monitoring, codes and standards, energy savings, etc.)
- BCHP increases productivity by improving health, comfort and environmental management
- BCHP is seen as both reliable and understandable, and functions at significantly lower cost
- BCHP systems meet business owners' concerns for lower energy needs, minimal capital financing, lower emissions, improved energy efficiency, and reliability
- Legislation and funding is approved for all energy efficient systems with the most advanced technologies
- On-site energy production achieves targeted efficiencies through free enterprise and with government legislation
- Marketing, the precursor to sales, has developed a "tool kit" of information on BCHP. It is designed to reach out and respond to the elements of the value delivery chain (e.g., ***Sweets Catalogue***)
- Integrated service providers offer single source energy, security, information and maintenance with the balance sheet
- Energy engineers are as important as mechanical design engineers
- BCHP is sold as (by) a utility, not as a capital (facility) expenditure
- BCHP systems offer positive return on investment and savings guarantees
- Educational materials, live and taped demonstrations, and software tools are used to bring designers, builders, owners and operators up to speed on BCHP components and systems

Actions to Achieve BCHP Sales and Marketing Destination

Focus Question: What are the key actions that need to be undertaken to advance BCHP sales and marketing to achieve the destination, goals, and vision of the BCHP Roadmap process?

In order to move the marketing and sales of BCHP components and systems forward, a number of actions need to take place. These actions include:

- Identification and development of marketing strategies that target niche markets for BCHP systems and improve the visibility of BCHP in the marketplace;
- Creation of industry partnerships to further the comfort level of building designers and component manufacturers in the viability of BCHP systems in retrofit and new applications;
- Development of government initiatives that illustrate leadership and provide funding sources for demonstration BCHP systems;
- Design and implementation of promotional activities that create interest and excitement for BCHP systems among building owners and managers; and
- Development of education and awareness programs that raise the level of understanding of BCHP systems as they compare to traditional HVAC installation and provide a conducive environment for BCHP in the design community.

In the marketing arena, niche markets for BCHP need to be identified and developed, to clarify the most cost- and energy-effective buildings for this technology. Load profiles for selected building types need to be monitored and analyzed. Links with trade allies, including component manufacturers, system designers, and utilities need to be developed so that marketing materials can be accurately developed and distributed by all parties. Computer software that compares BCHP systems with conventional HVAC systems will then lead to the creation of web-based load calculator programs that compare energy usage, costs, and environmental benefits of various BCHP components and systems.

Creation of industry partnerships is an important opportunity for marketing and selling BCHP components and systems. Technical information needs to be written and published in various industry publications, such as the AGCC newsletter, that reaches members of the gas cooling industry. "Champions" for BCHP must be identified within HVAC industry associations to encourage equipment and system designers, and building owners and managers to try BCHP equipment and systems. Standardized, insurable, and bankable BCHP service provider contracts must be created and used within the industry to reduce the risk of design or operation error.

BCHP demonstrations at federal government buildings remain a key action item for the BCHP design and construction community. The federal government is seen as a leader in moving this technology forward; doing so at federal buildings demonstrates leadership in a very positive way. On-line instrumentation at such sites, with links to appropriate web sites, would create national attention and interest in BCHP. The federal government should also fund research to quantify benefits provided by BCHP, such as humidity control, reduced emissions, indoor air quality, and energy efficiency.

BCHP systems need to be promoted within the architect/engineer community, as well as the building owner and procurement communities. All of these individuals drive the design and construction of buildings; they specify building loads through their A/E designs and develop bid specifications that drive the marketplace for specific heating, ventilation, and air conditioning equipment and systems. By promoting BCHP components and systems, through such activities as an annual prize for the most effective BCHP building design and operation, the design and build communities can readily see the positive impact that BCHP systems can make on building operations and energy costs.

Education and awareness are critical to successful marketing and sales of BCHP components and systems. Among the actions discussed, the most important education work needs to be addressed to policy makers (regulators, legislators, etc.) who so often create institutional roadblocks to innovative BCHP projects. Specific actions, such as creation of web sites, development of educational curricula and accreditation programs for training and certification of CHP designers and installers, all would assist the educational effort.

A detailed list of actions discussed at the marketing and sales breakout session can be found in Appendix E.

BCHP Marketing and Sales Action Plans

Focus Question: For the most important actions, what needs to be done, by when and by whom, to achieve the destination?

Among the top priority ideas and actions were the following:

- Identify and develop a portfolio of BCHP products and systems
- Quantify and document the benefits of BCHP
- Identify and develop markets for BCHP
- Develop industry alliances with customers
- Promote BCHP
- Educate policymakers on BCHP benefits

Action Plan #1: BCHP Portfolio

The goal of this action is to identify and develop a portfolio of BCHP products and systems that can be marketed and sold to the design and build communities. Among them are power sources, indoor air quality products, HVAC products, and software and controls for managing BCHP systems. By identifying and publishing specific products and system integration solutions, the size and value of the market for BCHP in terms of actual equipment needs can be more accurately evaluated. This effort would cost approximately $500,000 and be undertaken cooperatively by industry associations and government.

Action Plan #2: Quantify and Document Benefits of BCHP

This activity involves bringing the positive elements of building cooling, heating and power to the forefront of building design and construction to improve the technology's marketability and sales. Such positive elements as reduced absenteeism, operational risks, and price volatility are benefits worth publicizing. This task would involve actual quantification of reliability, power quality, environmental hazards and indoor air quality, energy costs, among other BCHP impacts. Software tools would need to be designed to model and compare BCHP components and systems in differing applications. This would be a government-led activity, with requests for quotes and proposals issued by DOE and work actually conducted by the national laboratories, marketing firms, universities, and environmental consulting firms. The estimated cost for this activity is $2.5 million.

Action Plan #3: Identify and Develop Markets for BCHP

The goal of this activity is to identify the appropriate market niches for BCHP, so that specific marketing and sales activities may be appropriately designed and targeted to the correct audiences. Steps to be undertaken include identification of target buildings – residential (multi-family), commercial, industrial, institutional, and identification of building usage, load profiles, energy needs, comfort levels, quality of indoor air, etc. Analysis of the roles and responsibilities of local, state, and regional government bodies as they affect the design and construction of buildings is also an activity. This work should dovetail with the development of the BCHP Roadmap, since market analysis is a critical issue for that activity as well.

This work would be conducted by market research companies, in coordination with industry partners, at a cost of $1.7 million.

Action Plan #4: Develop Industry Alliances With Customers

This activity is designed to create industry support for BCHP. Component/product manufacturers and system designers must buyoff on BCHP for them to create energy efficient and cost effective equipment for building installation. Unless industry supports this technology, institutional roadblocks will prevent their deployment in the time period required by the vision and roadmap. Industry associations, lobbyists, trade associations and others should be involved in this activity. Participation in meetings, seminars, and conferences, educational activities, Internet communications and training, and development of standards (e.g., ASHRAE, BOCA and other code associations) are all ways for alliances to be formed with industry. Forming alliances will take both money and time, and will require a “champion” within the appropriate industry. One million dollars is estimated to be necessary to form alliances on BCHP, to be appropriated with both government and industry funds.

Action Plan #5: Promote BCHP

Building cooling, heating and power is a technology “whose time has come.” However, it needs to be promoted, and thus become more acceptable in the building design and operations world. Marketing and sales of BCHP systems may seem threatening to the status quo of HVAC designers and owner/builders, as well as to utility providers, but if it is promoted more actively and honestly, it will become a more acceptable energy and building design option. One way to promote BCHP is to mandate its use for government buildings, and to train facility managers to utilize BCHP at other government sites. Results would then be publicly available to others and be promoted through both public and private avenues. This activity would involve government agencies, such as DOE, GSA, and EPA, as well as private consultants and contractors. The activity would cost up to $5 million, to be contributed by both government agencies and private industry.

Action Plan #6: Educate Policymakers on the Benefits of BCHP

Education is the key to marketing and sales for BCHP. A wide ranging education and training program should be undertaken to share the benefits of BCHP – energy efficiency, IAQ, reduced costs, and energy independence – with all those who are involved in designing, financing, building, and operating buildings. Outreach materials, such as brochures, newsletters, and case histories should be written and distributed at meeting sites; and both technical and general information on BCHP components and systems should be included in magazines/ newsletters and other documents published by trade and industry associations. Five million dollars is estimated for this activity, to be undertaken by both industry and government.

Market Destination

Highway

Installation Issues for Building Cooling, Heating and Power

In order to enable the widespread installation of BCHP systems in a wide variety of buildings, it will be necessary to create standardized equipment selection methodologies to minimize application engineering and non-recurring costs, and eliminate barriers. To achieve this, we need national standards for emission certification, electrical grid interconnects (physical and contractual), and performance ratings of BCHP packages. Installation technicians must be trained and certified. Training methodologies and standards should be updated regularly. Reliable control systems that integrate the BCHP package with building energy management systems and with the grid (where applicable) will be essential. BCHP systems must be adaptable to changing building requirements.

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BCHP installation methodologies, educational material, installation issues and support material need to be created.

- Develop BCHP Engineering Methodologies
- Develop and Conduct BCHP Curriculum/Certification for Technicians
- Identify and Remove BCHP Installation Barriers
- BCHP Installation Case Studies

Impact & Timeframe

1 1

Enough data exists today to assemble credible promotional material to be immediately effective.

BCHP Installation Breakout

This breakout session considered the means by which widespread use of BCHP packages in commercial buildings will be enabled by attractive, efficient installation procedures.

Processes that optimize the installation of BCHP systems must support the BCHP vision for 2020. In order to enable this process, barriers that slow the installation process must be removed. This can best be achieved by, among other actions, simplifying standards so that the amount of time spent qualifying each individual installation is minimized, as well as properly training and certifying installation personnel.

Installation Issues for Building Cooling, Heating and Power

Focus Question: What are the key "descriptors" for the installation of BCHP systems in 2020 for the vision and roadmap to be achieved?

Standards, education, reliability, and adaptability are the key components of a successful BCHP installation process in 2020. The discussion resulted in the following destination statement for installation:

> In order to enable the widespread installation of BCHP systems in a wide variety of buildings, it will be necessary to create standardized equipment selection methodologies to minimize application engineering and non-recurring costs, and eliminate barriers. To achieve this, we need national standards for emission certification, electrical grid interconnects (physical and contractual), and performance ratings of BCHP packages. Installation technicians must be trained and certified. Training methodologies and standards should be updated regularly. Reliable control systems that integrate the BCHP package with building energy management systems and with the grid (where applicable) will be essential. BCHP systems must be adaptable to changing building requirements.

Key Descriptors of BCHP Installation in 2020

- Education tools for contractors, consultants, inspectors, ESCOs, etc.
- Pre-engineered/standard BCHP plants to minimize installation efforts and to allow building designers a package to work into new buildings
- Turnkey project developers, installers, owners, operators, and merchant power providers
- Packaging (easy installation)
- Economic benefits to the building user or owner
- National standardized requirements:
  - Codes
  - Interconnect requirements
  - Emissions criteria
- BCHP components designed with ease of connectivity in mind; works in new and retrofit applications
- Educated work force
- CHP integration methodologies to reduce/eliminate engineering studies per site
- Design/selection software to make it economical to apply BCHP systems
- Characterization of standard applications best suited for BCHP
- Minimize application engineering with packaging and vendor support
- Standard design

Actions to Achieve BCHP Installation Destination

Focus Question: What are the key actions that need to be undertaken to advance BCHP installation processes to achieve the destination, goals, and vision of the BCHP roadmap process?

In order to arrive at the above destination and optimize the installation process for BCHP packages by 2020, actions must be undertaken in the areas of design and development technology, training and certification of technicians, and the development of national standards and accompanying legislation. Case studies on both existing and new systems must be undertaken, and all initiatives must be publicized.

The most important action is the development of generic BCHP methodologies. This would reduce the amount of “one-time engineering” that would be necessary for the installation of a BCHP system. Generic methodologies would be most effective in the equipment selection process as well as software selection and on-line troubleshooting.

The establishment of standard curricula and certification programs would also enable BCHP installations in 2020 for technicians. On-line training will be an important component.

Technical and legal barriers to the utilization of BCHP need to be removed through development of national emissions standards, performance-rating methods, and electrical grid interconnections. Interconnect requirements need to be standardized, and emissions permitting following certification should be eliminated. Government incentives for installing BCHP systems are also recommended.

Finally, a series of case studies involving both existing and new systems is needed to promote opportunities for BCHP systems to building owners.

Details of the “raw output” of discussions on these actions can be found in Appendix E.

BCHP Installation Action Plans

Focus Question: For the most important actions, what needs to be done, by when, and by whom to achieve the destination?

Four action plans, with two to four recommended projects each, are identified to achieve the destination for installation of BCHP systems in 2020. Detailed discussion results that led to development of these action plans can be found in Appendix E.

Action Plan #1: Develop BCHP Engineering Methodologies

The first plan, developing BCHP engineering methodologies, is meant to decrease or totally remove custom engineering for BCHP sites. Standardized methodologies reduce the installation cost of BCHP packages, making selection of the entire package as simple as possible to select a chiller system today. Projects to be undertaken include review and analysis of global CHP, development and dissemination of design tools, and development of performance ratings methods standard.

The $500,000 eight-month **Global Applications Review and Analysis** should start immediately and include a survey of current BCHP installations, a classification study, and an analysis of pertinent parameters. Resources include Internet capability and expertise. The project should be government funded but undertaken by industry (including trade organization participation) and should include international partners to make the review truly global.

When the above project is about six months old, it will have compiled sufficient data to begin the **Design Tools Development and Dissemination Project**. Based on survey and analysis data, a selection methodology would be developed, and relevant software designed and validated. Design tools would be made available on-line (where its frequency of use can also be monitored), and revisions made to the package whenever necessary. The baseline program would run for two years at a cost of $2 million. Follow-on and design upgrades would cost about $250,000 per year. Participants would include software and equipment manufacturers and architectural engineers. Building owners and operators would need to be included to provide on-site input. Information on equipment performance would be requested from vendors. Expertise in other fields, such as computer software and BCHP technologies, would be used as well in development of design tools.

The design methodology plan incorporates **Development of a Performance Ratings Method Standard.** Appropriate standard setting bodies need to be identified and standards developed. If such a performance standard project is started immediately, it may take up to two years to identify proper standard setting bodies and "sell" them on the idea. In the general area of standards development, an additional five years would be required to fully develop BCHP performance standards. Government funds would support leadership by standards organizations and their manufacturers and users. This project is estimated at an initial cost of $500,000 and would be continued at $250,000 for each subsequent year.

Action Plan #2: Develop and Conduct BCHP Curriculum/Certification for Technicians
Specific training and certification to qualify BCHP installation technicians will lead to enhanced reliability of installed BCHP systems and improved confidence from system owners. This Action Plan is divided into separate curriculum and certification projects.

Curriculum Development should begin immediately with identification of who should develop the installation curriculum. Since the global application review results (described above) should feed into this project, actual curriculum development should begin six months later. Curriculum design should be completed within one year at a cost of $750,000 to one million dollars, and should partially include an on-line "virtual" BCHP system. Vendor-donated BCHP components would allow the design of a hands-on training option as well. The curriculum should be updated periodically and continuously disseminated via workshops and academic institutions. The dissemination process should be partially funded by user and contractor associations. Participants should include academia, equipment vendors, and contractor associations. Required resources (aside from donated equipment) would be composed of expertise and a website.

Development of a Technician Certification Program would run in parallel with the curriculum project and require about two years. The project would include establishment of a certification development committee, design and validation of a certification test, and promotional activities that fully advertise the test. Promotion would begin about six months before the end of this project, and would then be ongoing. Project participants would include such organizations as the North American Technician Excellence (NATE) Association, as well as contractor and manufacturer organizations.
A certification program would cost about $2 million to develop and about $500,000 per year to

continuously promote the program. Resources include the expertise of a testing organization and a website to serve as an on-line certification testing location.

Action Plan #3: Identify and Remove BCHP Installation Barriers

This action addresses the need for national standards for BCHP and development of legislative approaches to support standards development. By removing requirements for unique and custom design standards at each BCHP site, installation costs would be minimized. The plans include a revamping of emissions certifications and interconnect standards, government incentives for BCHP, and improvements to current building codes and standards to include BCHP systems.

A "One-Time" Preemptive Air-Emissions Certification would include development of the certification standard and national legislation to institutionalize it. This project would start immediately, require about two years to develop the standard, and about five years to pass legislation, although lobbying efforts could begin in parallel with standards development. The cost of standards development is estimated at about $500,000, but the cost of legislative action is unknown. The development effort would be led by DOE and EPA, and would involve vendors, trade associations, and environmental advocacy groups. Trade associations and vendors would lead the lobbying effort. A "champion" in Congress would represent a huge benefit for the project.

National Adoption of a Reasonable Interconnection Standard (both Technical and Contractual) would take the same path as the emissions standard described above. One exception, however is that technical interconnect standards exist, and need only to be extended nationally. Contract standards need to be both developed and implemented nationwide. Development of the contractual standard would take two years and is estimated to cost $2 million. Parallel legislative actions (both technical and contractual standards) would require five years, again at unknown costs. These efforts would be led by IEEE and DOE, and would include vendors, utilities, energy service companies (ESCOs), regulators, and a congressional "champion."

Barriers to BCHP installation could also be removed by development of ***Government Incentives for BCHP***. Such an effort would include defining BCHP (the Canadian model, for instance, uses an efficiency of 60%), passing legislation to create appropriate and fair incentives for using BCHP systems, implementing the incentives, and monitoring and measuring their use and effectiveness. Development of these incentives would start immediately, require two years to define qualifying criteria, and a third year to legislate. Implementation and follow-up would be ongoing after the third year. The cost of implementation and follow-up is estimated at $500,000 million to define qualifying criteria, plus an unknown amount to pass legislation. Implementation, monitoring and analysis would likely start at $250,000 million for the first year incentives were in force, and would grow as more systems qualified. This project should be led by DOE, and should include BOMA, other associations, trade associations, and a legislative "champion."

ASHRAE Standard 90.1 sets minimum energy standards for buildings at least two stories high. Development of an Extension to ASHRAE 90.1 to cover BCHP systems would facilitate removal of barriers. This effort would initially be financially supported by the government, and would be coordinated through ASHRAE, using their consensus process. It would begin immediately, costing about $250,000 per year, and is estimated to last 2-5 years.

Action Plan #4: BCHP Installation Case Studies

Case studies involving both existing and new installations are needed to determine the state of the art of BCHP system installations and to validate their benefits.

Documentation of Existing Installations would involve a survey of existing BCHP systems, data analysis, and documentation and dissemination of results. Industry and its trade associations as well as academia and building owner support would carry out this project. Estimated costs are $750,000 to one million dollars, over a one-year time frame.

A second project would ***target BCHP technologies in New Demonstration Projects***. Following development of a scope of work, design tool methodologies, and selection of buildings as test platforms, BCHP systems would be installed, monitored, and evaluated. Results would be disseminated widely, with the help of professional public relations and outreach professionals. Each BCHP technology would be demonstrated at three sites; each site would demonstrate multiple technologies. As a major effort, involving industry, consulting engineers, trade organizations, and building owners, this project would cost $2-10 million per demonstration

Market Destination

Highway

Operation Issues for Building Cooling, Heating and Power

For market implementation to succeed, BCHP operational results must be:

- Tangible, apparent, and profitable to commercial building owners and occupants;
- Adaptable to changing technology and market influences;
- Flexible -- in real time -- to respond to changing building conditions;
- Networkable with outside systems including sale and purchase in energy markets; and
- Interfacable providing simpler human interaction and higher reliability.

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Initiate the following operations programs:

- Develop 1st generation optimal operating strategies with simple human interfaces
- Provide real-time measurements for different BCHP technologies
- Establish mechanisms to integrate BCHP with energy markets
- Conduct BCHP demonstrations to verify economics and performance
- Educate key participants

Impact & Timeframe

1 1

Operations education, training, controls, feedback loops and demonstrations need to be in place as sales occur.

Like many BCHP activities the time to start is now.

Operation Issues for Building Cooling, Heating and Power Breakout

This breakout session identified research, development, education, training, and other activities that will enhance information, tools, and processes for operating BCHP systems in all types and sizes of commercial buildings. For BCHP to be the "...preferred method of energy utilization in buildings", as called for in the vision, BCHP operations need to be at a point where system performance is optimized and customer satisfaction levels are high. BCHP systems will be competing with other types of building energy and power technologies. Operational considerations could be key for BCHP systems to be accepted and used in the marketplace.

BCHP Operations Destination

Focus Question: What are the key "descriptors" for the operation of BCHP systems in 2020 for the vision and roadmap to be achieved?

A key trend affecting the future operation of buildings is the use of information and telecommunications technologies for automation and remote control of various functions. BCHP systems need to be able to operate in a seamless fashion with other building systems and with outside energy providers. Although BCHP systems will necessarily involve the use of advanced energy and power technologies, the operation of these systems cannot be perceived as burdensome and complex. Simplicity in design, installation, and operations is paramount for BCHP to make successful inroads in the commercial buildings market.

In addition, BCHP systems need to provide information on the status of their performance, in real time, to a variety of audiences, including building owners, occupants, operators, and utilities/energy service providers. Data acquisition and reporting systems are needed to monitor and report on a variety of critical BCHP operational variables, including efficiency, humidity, emissions, cost, and profitability.

The following is the destination statement developed in the breakout session.

Key Descriptors of BCHP Operations in 2020

Assumptions	Human Factors	Value Proposition	Interconnection	Responsive to Change
BCHP systems are commercial and integratable	Easy-to-use and simple interface	Owners/users get feedback on value delivered	Operates in concert with other cooling, heating, and power systems	Seamless response to changing occupant needs
BCHP systems are competitively priced	BCHP systems are non-intrusive	BCHP operators make above average profits	Able to operate remotely	Provides real time cost and performance feedback
BCHP is used in all types of commercial buildings	BCHP systems need no additional manpower or attention	Customized systems are optimized for various users	Provides energy to the grid	Retrofittable
Bandwidth is inexpensive and plentiful	Run with automated controls		Links in-and-out of buildings	Plug&play
			Link to energy procurement	Upgradable as new technologies come on-line

For market implementation to succeed, BCHP operational results must be:

Tangible, apparent, and profitable to commercial building owners and occupants;
Adaptable to changing technology and market influences;
Flexible -- in real time -- to respond to changing building conditions;
Networkable with outside systems including sale and purchase in energy markets; and
Interfacable providing simpler human interaction and higher reliability.

Actions to Achieve BCHP Operations Destination

Focus Question: What are the key actions that need to be undertaken to advance BCHP operations to achieve the destination, goals, and vision of the BCHP Roadmap process?

A variety of actions are needed to insure that operation of BCHP systems in the future meet the requirements listed in the destination. The scope of needed activities covers research, development, education, and policy initiatives. (See Appendix E for detailed list of the actions identified in the breakout session. Included are the results of a vote that was taken to determine the top priority actions.)

One of the most important areas of development is the need for optimal operating strategies for BCHP systems. Because BCHP involves a variety of products and services — heat, power, cooling, dehumidification, air quality — to meet the energy needs of a diverse market of commercial buildings, ownership and occupant requirements, and climatic conditions, there cannot be a single optimal operating strategy that satisfies all of the potential needs. Actions are needed to catalog the variety of possibilities and match those needs with the various BCHP system configurations to determine a discrete set of operating strategies.

Another important area of development is the need for simple and effective interface among operators, systems, and users. This includes sensors, data acquisition, software, and communications technologies. A critical aspect of this interface is the need for real-time performance measurement and reporting about a variety of variables, and the ability to analyze and synthesize the measurements into usable information for operators and users. Measurements are needed for traditional factors like fuel use, temperatures, costs, and efficiency, as well as for non-traditional factors like humidity, indoor air quality, and profitability/value. This broad spectrum of measurements is needed so that the full set of benefits of BCHP systems can be demonstrated, in real time, for operators, owners, and users. Demonstrating the operational advantages could be an important ingredient to the marketing success of BCHP systems.

To achieve this high level of operations, further development is needed in several areas including operating specifications and standards. Standardization of BCHP operating procedures will not be easy because of the wide variety of building types and applications in which BCHP will need to apply. Also needed is hardware and software to support BCHP communications networks within buildings and interconnection to outside service providers, including maintenance contractors, energy service companies, and fuel and power providers. Mechanisms are needed to enable two-way information flow between BCHP systems and the utility grid, including provisions for enabling real-time, buy-sell transactions and information on grid operations to meet power, voltage, and VAR requirements.

Another important area of development is education, outreach, marketing, and training. Key audiences for BCHP operations need to be identified and informed about operational requirements and constraints. BCHP needs for communications and data acquisition and reporting networks should be brought to the attention of architects and building designers, and the contractors that specify BCHP and other buildings equipment. A “holistic” approach to the design and operations of commercials buildings is the proper context in which to educate various audiences about BCHP. A program to demonstrate BCHP systems and operations in a wide variety of building types and climate zones could be highly beneficial.

BCHP Operations Action Plans

Focus Question: For the most important actions, what needs to be done, by when and by whom, to achieve the destination?

Among the top priority actions and ideas were the following:

- Develop 1st generation optimal operating strategies with simple human interfaces
- Provide real-time measurements for different BCHP technologies
- Establish mechanisms to integrate BCHP with energy markets
- Conduct BCHP demonstrations to verify economics and performance
- Educate key participants

Detailed summaries of the plans for these five priorities can be found in Appendix E.

Action Plan #1: Optimal Operating Strategies

The purpose of this action is to develop and test a logic structure for BCHP operations to optimize performance for a variety of technologies and applications. This action will help make the benefits of BCHP systems tangible, apparent, and profitable to commercial building owners and occupants, and will help provide a simpler human interface for BCHP systems operations. The action involves a study of the value factors that are of greatest importance to building owners, occupants, and operators and the development of appropriate software and hardware for optimizing BCHP performance over a range of operating conditions. A prototype would be built and tested. This effort needs to start right away so that the 1st generation operating system can be ready within two years. The Department of Energy would be a key sponsor of the activity and performers include the national laboratories and consortia of equipment manufacturers, building owners and operators, and utilities. Funding required for this effort is approximately $20 million over two years. This amount includes government funding and industrial cost sharing.

Action Plan #2: Real-Time Measurements of BCHP Operations

The purpose of this activity is to develop and test hardware and software that acquires data and reports on the performance of a variety of key operational parameters in real time. Appropriate sensors and data acquisition systems would be developed to analyze, and report key information to building owners, operators, and occupants. Products resulting from this action would enable BCHP operations to demonstrate tangible benefits, respond to changing conditions, and network with other systems including all aspects of building operations and interconnections with energy providers.

The action plan would proceed in two phases and be conducted in parallel with the effort to develop optimal operating strategies discussed above. The first phase would start immediately and be finished in one year at an approximate cost of $2 million. This first phase would involve a series of studies to determine the minimum set of measurements needed, communications requirements, and sensor requirements. The second phase would be conducted over a subsequent two-year period at an approximate cost of $20 million to develop and test a prototype measurement system. The Department of Energy would partially support this activity, with cost sharing requested from industry. Performers would include the national laboratories and a consortium of equipment manufacturers, information companies, and controls manufacturers.

Action Plan #3: Mechanisms to Interconnect BCHP with Energy Markets

The purpose of this activity is to develop a set of guidelines and protocols that are consistent around the country, under which utilities and BCHP owners/operators can communicate in real time, exchange data on operational status, and conduct buy-sell transactions. This would enable BCHP operations to be adaptable to changes in technologies and market conditions, respond to changing conditions in buildings, and communicate with outside energy service providers.

This action involves the establishment of a set of protocols for BCHP/utility information exchange, and would probably require regulatory action by state public utility regulatory authorities and the Federal Energy Regulatory Commission. Rules would be needed for buy-sell transactions. These rules would need to be as consistent as possible across utility service territories. Regulatory barriers to such rules would need to be identified and proposals developed to eliminate them. Creation of operating protocols for BCHP/utility information exchange would need to be accomplished in a collaborative process, possibly under the auspices of a trade association or a professional society such as IEEE or ASHRAE. This action would be accomplished in two phases over a three-year period at an approximate cost of $5 million. The first phase would begin right away and would focus on regulatory analysis for establishing rules for the exchange of information. The second phase would begin after the first year and would involve development and testing of BCHP/utility information exchange systems.

Action Plan #4: BCHP Demonstration Program

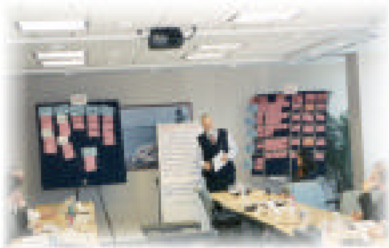
The purpose of this action is to demonstrate the benefits of BCHP systems to potential users and the community of building professionals, including architects, designers, contractors, owners, operators, and energy services companies. This demonstration effort would not be confined to operational components but would cover all aspects of BCHP systems installation, operations, and maintenance. The action would involve the development of a “quasi-experimental” sampling plan to select a range of building types and climate conditions, including both new construction and retrofit applications. The plan would include a strategy for instrumenting both “treatment” and “control” buildings with BCHP and measurement systems.

This effort would be conducted as a three-phase, eight-year program, involving over 50 buildings, at an approximate cost of $60 million. The first phase would take two years and involve development of the measurement strategy and selection of candidate sites. The second phase would also take two years and involve building instrumentation, data collection, and reports on the initial analysis results. The third phase would take four years and involve more detailed analysis, including both cross-section and time series evaluations of BCHP performance.

Action Plan #5: Educate Key Participants

The purpose of this activity is to develop and disseminate materials on key aspects of BCHP systems and operations to a variety of audiences. The initial focus would be on decision makers, including potential BCHP owners and operators, sales and interconnection staff from utility distribution companies and energy service providers, and regulatory officials. The action would involve market research and targeting of these key audiences to develop a better understanding of their need for BCHP information, development of educational materials, and use of communications mechanisms including the Internet. The effort would start right away and the first three years of the program would cost approximately $3 million. It is expected that the need for education would continue over the life of the BCHP program and would respond to changing needs of various audiences. At later stages, the focus would shift to education of general audiences and training programs for design, operations, and maintenance professionals.

Market Destination



Highway

Maintenance Issues for Building Cooling, Heating and Power

In the year 2020, BCHP systems of choice in buildings should have high reliability with minimal maintenance, self-diagnostics with automated remote monitoring, and self-correcting capability. A network of well trained, multi-disciplined, nationally certified BCHP technicians should support these environmentally friendly systems of the future.

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Initiate the following maintenance programs:

- Educate Technicians
- Develop a BCHP Certification Program
- Develop a Protocol for BCHP Controls
- Educate Design Engineers and Product and Service Providers
- Develop Economic Incentives

Impact & Timeframe

1 1

Maintenance is often left to chance. In providing more complex equipment, BCHP systems must be designed for ease of maintenance and provide operators with reliable warning of impending problems.

Program development needs to work in parallel with product development.

Maintenance Issues for Building Cooling, Heating and Power

Proper maintenance of BCHP systems, packaged designs for minimal maintenance requirements and anticipatory control systems will minimize the cost and difficulty of owning and operating them. The BCHP vision for 2020 should include maintenance procedures that ensure that installed BCHP systems are operating at, or near, top performance levels. Actions such as 1) development of a BCHP building and equipment certification program; 2) building BCHP systems with self and remote diagnostics; and 3) training and certifying programs for technicians will provide support for future maintenance of BCHP systems.

BCHP Maintenance Destination

Focus Question: What are the key "descriptors" for the maintenance of BCHP systems in 2020 for the vision and roadmap to be achieved?
Key descriptors for improved BCHP maintenance were brainstormed. Descriptors such as remote diagnostics (direct feedback), reliable and dependable performance, continued education and certification of technicians, operators, owners, and an established network of maintenance providers were determined to be essential maintenance needs.

The destination statement for maintenance that was developed at the breakout session follows:
In the year 2020, BCHP systems of choice in buildings should have high reliability with minimal maintenance, self-diagnostics with automated remote monitoring, and self-correcting capability. A network of well trained, multi-disciplined, nationally certified BCHP technicians should support these environmentally friendly systems of the future.

Descriptors for Maintenance of BCHP Systems in 2020

- Self diagnostics
- Remote diagnostics
  - Direct feedback to service organizations
- Self-monitoring
- Automated troubleshooting
- Reliable and dependable performance
- Consistent performance
- 20,000 hour or 3 year service interval
- Low operating costs
- Affordable initial cost
- Intelligent communication
- Safety
- Part of single system electronics
- Integration friendly
- Continued education and certification
  - Technicians
  - Operators
  - Owners
- Multi-purpose technicians
- Economic maintenance costs
  - In 2020, costs are 1/3 less than in 2000
- Preventive maintenance
- Established network of maintenance providers
- Simple service requirements
- Flexible maintenance contracts

Actions to Achieve BCHP Maintenance Destination

Focus Question: What are the key actions that need to be undertaken to advance BCHP maintenance to achieve the destination, goals, and vision of the BCHP roadmap process?

In order to arrive at the BCHP maintenance destination by 2020, actions must be undertaken in the areas of research and development, education, incentives, standards, system integration, and building certification. (See Appendix E for a list of actions identified in the breakout session.) Ensuring that BCHP systems are relatively maintenance free and user-friendly is very important for a successful future. In order to get to this level, other areas within the BCHP realm must be researched and developed.

For instance, developing BCHP controls is a key technical action item. These controls should be sophisticated, with diagnostics that enable the BCHP system to self-correct. Looking into the future, it is essential that BCHP controls be monitored remotely via the Internet. Once developed, they should be readily available and inexpensively integrated into packaged BCHP systems. By improving operational controls, the BCHP system will be easier to operate and faster to troubleshoot. This will ensure low maintenance requirements and costs. Also, within the area of research and development, it is important to apply maintenance feedback to improve equipment. Often new ideas are developed and incorporated into building systems without asking technicians and users for input. By reaching out to end-users and incorporating their needs into BCHP systems, maintenance requirements on the systems should be lower.

Education is another major area for improvement within the maintenance process. Technicians need to be trained and certified in BCHP system operation. This means that a multi-faceted curriculum should be established to cover a broad range of BCHP technology. Design engineers and product and service providers should also be adequately trained in maintenance procedures.

In order to market BCHP systems and promote their low maintenance and ease of use, purchase incentives should be developed and marketed to potential end-users. Such incentives may be financial (rebates, tax credits) and/or educational. Once market recognition has been established, larger numbers of BCHP systems will be sold and further advancements in maintenance can take place.

Before maintenance can play a key role in the BCHP Vision, general component and reliability standards need to be developed, as well as standards for linking BCHP diagnostics into the system. Most importantly, codes and standards should be developed for BCHP building certification. Developing a certification program is a key element in the maintenance process highway.

In terms of system integration, sensor controls and advanced diagnostics need to be incorporated into BCHP models. Such controls and diagnostics will improve operation of the system and allow operators to quickly pinpoint system problems and get back online.

Developing a successful buildings certification program is a very important action item in the BCHP maintenance arena. By validating the performance of existing equipment and systems, certification standards can be developed and applied to the program. Individual equipment components should also be certified individually. This effort would give potential investors higher confidence in the reliability and health of the system and would also encourage high levels of maintenance quality.

BCHP Maintenance Action Plans

Focus Question: For the most important actions, what needs to be done, by when, and by whom to achieve the destination?

Five action plans have been identified for achieving the maintenance destination of BCHP systems in 2020.

Action Plan #1: Educate Technicians

A national certification program should be developed to educate technicians on BCHP equipment and systems. This program should be multi-disciplinary and qualify technicians in each technical area (e.g., engines, chillers, heat exchangers, turbines, etc.) before receiving certification.

In order to complete this action item, several milestones must be accomplished. First, a program plan and curriculum must be developed, and partner schools recruited to accept the curriculum. Instructors must also be identified and trained. An overall management organization (i.e., Refrigeration Service Engineering Society) should be established to direct partner schools and determine the mechanism for obtaining continuing education credits associated with the program. Once the certified BCHP program is up and running, a co-operative program can be established to enable qualified technicians to transition easily into the marketplace. These certified technicians would be able to expertly satisfy the maintenance needs of BCHP equipment and systems.

This project would begin immediately and last approximately three years. Key participants in the process would include vocational technology schools and members of academia, as well as sponsors such as the Institute of Electrical and Electronics Engineers (IEEE), the American Gas Cooling Center (AGCC), Association of Energy Engineers (AEE), the Air Conditioning Contractors of America (ACCA), the American Gas Association (AGA), and the Air Conditioning and Refrigeration Institute (ARI). The project has an estimated cost of one million dollars per year, which is predominately associated with the cost of a full-time program manager. Certification fees would offset the cost of the program.

Action Plan #2: Develop a BCHP Certification Program

There are two parts to this activity. BCHP certification standards would be developed, followed by development and maintenance of a certified buildings program. Minimum standards would be based on metric source energy ($/ft^2/yr). Once developed, these BCHP standards would be applied to a buildings CHP certification program. Such a program, supported in part by DOE, would certify the whole building containing the packaged BCHP system. An administrator would run the program after the certification criteria have been developed.

This activity would cost approximately $1 million per year for the five years it would take to complete the certification program. The development of BCHP certification standards would be an on-going process. In addition to government, manufacturer and IEEE involvement, the National Association of Home Builders (NAHB) would play a key role in the certification program.

Action Plan #3: Develop a Protocol for BCHP Controls

Diagnostic and control tools may be utilized to reduce BCHP equipment repair and service time. These tools handle whole building operations and are capable of remote monitoring and diagnosis. It is essential that BCHP controls are designed with future packaged systems in mind. They should be easily integrated into plug-and-play systems and be compatible with up-to-date BCHP systems. At the same time, controls should be Internet compatible and simple for operators and technicians. To initiate development of controls, a protocol for control requirements should be developed. Developing synergies among equipment, building, and central system-oriented requirements would follow. The controls would then be modeled. Once a control prototype is developed, it needs to be rigorously marketed to manufacturers so it may be incorporated into BCHP equipment and systems. This project is estimated to last up to three years at a cost of approximately one million dollars a year until the protocol is accepted and adopted. Costs would eventually decrease to $100,000 a year. Equipment and control manufacturers and energy service companies would play an essential role in development of the protocol for BCHP controls.

Action Plan #4: Educate Design Engineers and Product and Service Providers
Education for technicians, building owners and managers, and other key BCHP players is essential if future maintenance requirements are to be met. While BCHP technicians should be educated and trained to provide competent and speedy maintenance of BCHP systems, it is equally important that others working with BCHP systems be educated.

Design engineers seem to have misconceptions about maintenance requirements of BCHP equipment and systems. An open communications process among design engineers, technicians, and others is necessary to provide continuous feedback to manufacturers so that maintenance requirements decrease even further in the future. The design curriculum at colleges and universities should include BCHP system design, operations, and maintenance to educate future designers on the benefits of BCHP systems. In addition, field engineers should be required to participate in self-study programs. Finally, partnerships should be established with organizations such as the Building Owners and Manufacturers Association (BOMA) and the American Institute of Architects (AIA). Such associations should be encouraged to learn about BCHP systems and make educational materials available to their members. Costing an estimated one million dollars a year for the next two to three years, this education effort will not only result in the production of important educational materials but also increased awareness of the benefits of BCHP systems.

Action Plan #5: Develop Economic Incentives
Providing financial incentives for building owners and operators to install and maintain BCHP systems will be a key ingredient of their future marketability. One such incentive would be a BCHP tax credit, available to building owners.

Monetary rewards for building owners and managers who become certified and provide operations data should also be considered. Such data should be accumulated in a database and made available to component manufacturers.

Government incentive support should eventually be combined with support from industry partners. As BCHP systems prove to be reliable and cost effective, their economic value needs to be researched and documented. Economic benefits should then be compared to program goals and objectives, to more clearly articulate the BCHP vision for 2020.

Financial institutions, insurance companies, and real estate appraisers should be approached as resources to create financial incentives for BCHP. Building owners and operators should be encouraged to provide data to a database manager, who would be an integral part of a BCHP “SWAT” team. In order to get economic incentives in place, it is estimated that this project would cost $200,000 a year for three years.

Policy and Regulations Destination
4/00 (Rev 7)

Policy and regulations within the energy and environmental industry are particularly volatile and are expected to be under transition over the course of the next decade.

Government policy clearly adds a level of uncertainty over generally predictable technological and economic development. Currently, energy restructuring is creating uncertainty and delaying technical and economic decision-making. Government efforts to address climate change also have the potential to significantly impact the building industry.

Government policy in the energy and environmental areas can also be a stimulus. For example, government policy in certain European countries is stimulating BCHP projects.

Twenty-four participants, representing government, national laboratories, academia, utilities, the building industry, consulting and trade associations, manufacturers, and research and development organizations worked together to develop action plans for improved BCHP policies. Similar to the previous workshops, the policy workshop was sponsored by the U.S. Department of Energy.

The workshop included two plenary sessions that provided participants with information on BCHP policy issues in the areas of Building Codes and Standards; Environ-mental Regulations, Permitting and Siting; Tax/Financing Issues; and Utility Practices. Each presentation provided a “snapshot” of policy issues which impact development of BCHP systems in buildings. A summary of these presentations appears in Chapter II of this report.

The second plenary session was a facilitated discussion of BCHP Policy Coordination Needs and Opportunities. The purpose of this session was to discuss policies specifically related to BCHP that may hinder its full market deployment and the organizations and institutions that have a role to play in addressing these policies. A summary of the discussion and the resulting policy matrix appear in Chapter III of this report.

Participants were divided into two Breakout Sessions on the second day of the workshop. The first group addressed Administrative Actions and Utility Policies and Practices; the second group addressed Energy Codes (Site/Source) and Building Codes and Standards.

Each Breakout Session addressed two focus questions:

> What are the key actions needed to address administrative and utility (energy and building codes and standards) policies and practices?
> For the top priority actions, what needs to be done, by whom, when, and with what resources?

The two groups presented their results in the form of “storyboard” reports.

Four presentations were given on policy issues related to building cooling, heating, and power. David Conover, CEO of National Evaluation Service, Inc., discussed the impact of building codes and standards on BCHP. He discussed building codes and standards that are institutionally constraining as well opportunities for BCHP and U.S. and international initiatives to develop and implement codes and standards for some BCHP technologies. He suggested activities that could be jointly undertaken by the building industry, building code organizations, and government agencies to facilitate adoption and implementation of codes and standards that will improve the integration of BCHP components and systems in buildings.

Joseph Bryson, CHP Program Manager in the Climate Protection Division at the Environmental Protection Agency gave a presentation on the environmental benefits of combined heat and power. He spoke of the nature of environmental benefits for buildings cooling, heating, and power, including improved efficiency, lower polluting fuels, and regional emission reductions through displacement of grid-supplied generation. He described EPA's efforts to promote the use of CHP in buildings, through activities such as:

The set-aside for energy efficiency projects in the NOx model trading program, and
The Energy Star CHP Award. The Energy Star CHP Award is a new initiative that awards facilities, which utilize high-efficiency combined heat and power.

He posed a number of critical issues for small scale (<1 MW) distributed generation, including how to ensure that these systems are preferable to central station generation.

Bonnie Suchman, of Troutman Sanders, and Brent Alderfer of Competitive Utility Strategies spoke about tax- and utility-related regulatory and legislative barriers to BCHP. Ms. Suchman presented information about tax legislation currently being considered by Congress that would lower the depreciation schedule for the useful life of buildings using combined heat and power. Rather than a straight-line depreciation schedule, owners of buildings utilizing BCHP could recover their investment in less time, thus improving the cost-effectiveness of that investment in new technology. She also discussed a proposed CHP tax credit that would improve the investment picture of buildings using combined heat and power.

Mr. Alderfer discussed regulatory barriers to BCHP, including interconnection requirements, high standby charges, exit fees, and other anti-competitive policies that threaten the widespread use of BCHP. He encouraged participants to work toward a uniform regulatory policy for combined heat and power that would provide a receptive environment for this technology.

The plenary session provided an opportunity for participants to discuss policy issues that impact or are impacted by BCHP and organizations and institutions that have either a lead or supporting involvement in those issues. The result of the discussion is shown in the BCHP Policy Coordination Matrix below. As shown in the matrix, a number of organizations play a lead role in many policy issues; others play supporting roles; and still others are not involved in an issue at all. Through this process, it became clear that there are a variety of organizations involved in addressing policy and regulatory barriers regarding the use of BCHP systems. There is a need for better coordination so that specific organizations can play more effective roles in breaking down policy barriers to BCHP.

BCHP Policy Coordination Matrix

	Environmental Siting and Permitting	Tax Provisions	Utility Inter-connection and Practices	Building Codes and Standards	Energy Codes	Administrative Actions
Universities				☑	☑	☑
ASHRAE				☑	☒	
U.S. CHPA/IDEA	☑	☑				☑
DPCA			☒			☑
ASME				☒		
BOMA	☑	☑		☑	☑	
Building Code Orgs.				☒	☑	
Energy Facility Siting Agencies	☒					
IEEE			☒	☑		☑
NFPA				☒		
EPA	☒	☑			☑	☒
STAPA (Air Permits)	☒					
DOE (Including FERC)	☑	☑	☒	☒	☒	☒
DOE Labs			☒	☑	☑	☑
Dept. of Treasury		☒				
State Depts. Of Revenue		☒				
Gas Industry	☑	☑	☑	☑	☑	☒
Electric Industry	☑	☑	☒	☑	☑	☒
NARUC/PUCs			☒		☑	☑
Manufacturers/Developers	☑	☑	☑		☑	☑
UL			☑	☒		
ANSI				☒	☑	
Unions						
Land Use Planning Organizations	☒					☒
NAHB		☑		☒	☑	☒
Congress		☒	☒	☒	☒	☒
DOD	☒					☒
State Energy Offices	☒	☑	☒	☒	☒	☒
GSA	☒				☒	☒
State Legislators	☒	☒	☒	☒	☒	☒

☑ = Lead Organization ☒ = Supporting Organization

Policy and Regulations Destination

Highway

Administrative Actions and Utility Policy/Practices

The American people will rise to any occasion to defeat an enemy, conquer a disease or fly to the moon. However, regarding energy and the environment, there is no clear political consensus; and, in fact, the government behaves, in its standards, regulations and operation, as if resource conservation and the environment are secondary matters.

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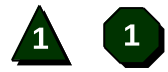
A variety of actions are needed to address the needs of federal, state, and local policy officials. Examples of administrative actions that could be undertaken by federal, state, and/or local agencies to promote the use of BCHP systems include policy guidance, Executive Orders, research and development initiatives, technology transfer efforts, and education and awareness campaigns. Examples of utility pricing and practices that could be undertaken to promote the use of BCHP systems include steps by federal and state regulatory authorities such as notices of inquiry and proposed rule making, regulatory orders, and public hearings.

Impact & Timeframe



Focusing the BCHP industry on clear national goals and fixing existing contradictory standards, regulations and operating practices is an essential beginning for success.

This process must begin immediately and proceed quickly.

Actions to Address Administrative and Utility Policy/ Practices

What key actions are needed to address administrative and utility policy/practices?

A variety of actions are needed to address the needs of federal, state, and local policy officials. Examples of administrative actions that could be undertaken by federal, state, and/or local agencies to promote the use of BCHP systems include policy guidance, Executive Orders, research and development initiatives, technology transfer efforts, and education and awareness campaigns. Examples of utility pricing and practices that could be undertaken to promote the use of BCHP systems include steps by federal and state regulatory authorities such as notices of inquiry and proposed rule making, regulatory orders, and public hearings.

The level of awareness about BCHP technologies and practices among federal, state, and local policy officials remains at relatively low levels. As a result, all actions to promote the use of BCHP systems must be aimed at providing more and better information to decision makers at a level of detail they can understand, when the information is needed for decision making, and in forms that can be easily used.

On the administrative side, the action that could have the greatest impact is an Executive Order from the President of the United States requiring the use of BCHP systems in all federal facilities. This action would contribute to raising awareness and understanding of the potential benefits of BCHP systems. Such an Executive Order would be designed to be consistent with existing orders covering the expanded use of energy efficiency and renewable energy technologies in federal facilities. However, special focus is needed on the use of BCHP systems because of their unique applications, complicated technical considerations, and newness of the concept. Unlike other energy efficiency measures, such as energy efficient lighting, the use of BCHP systems requires interconnection and integration with existing cooling, heating, power, and humidity control equipment in buildings, and with the electric[10] and natural gas distribution grids. This added complexity means that different approaches are needed to accomplish BCHP in federal facilities than are being used for other energy efficiency measures, hence the need for a special Executive Order.

There are two actions on the utility policies and practices side that could have a large impact on fostering the use of BCHP systems. Interconnection of BCHP systems with the electric grid can be an expensive and time-consuming process. There are technical issues involving interconnection equipment and procedural issues involving utility policies and practices. BCHP shares many of the same interconnection problems as other distributed energy systems so there is ample opportunity for collaboration with other groups promoting distributed energy resources.

Many electric utilities have traditionally viewed distributed energy resource options like BCHP as a competitive threat. Expanded use of customer-owned generation will eventually result in a loss of sales to the utility. Substitution of natural gas-using equipment for electricity-using equipment also results in a loss of electricity sales. However, as a result of utility restructuring and other drivers, the energy services market is changing dramatically. Many utilities are forming affiliated energy services companies to compete in unregulated markets. Mergers of electric and natural gas utilities are on the rise. As a result, there are new opportunities to identify potential partners for collaboration on BCHP in the utility sector. Action is needed to identify incentives for the electric power industry to view BCHP in a more positive manner.

[10] Eclectic grid interconnection may or may not be required depending on the particular application

List of Actions – Federal and State Administrative Actions and Utility Policy/Practices

National Policy Initiatives	Federal Facilities	Financial Incentives	Utility Pricing and Practices	State Policy Initiatives	Education and Outreach
Establish BCHP Executive Order ◆◆◆ ◈◈◈ - Covers BCHP in federal facilities - Integrates BCHP across agencies (GSA, EPA, DOE) - White House uses to promote energy policies	Require that BCHP be installed in all new federal facilities and install retrofits where feasible and cost-effective ◆◆ ◈◈◈ - Have DOD, GSA lead by example - Include in the proposed Executive Order	Create incentive mechanisms for electric power industry to embrace BCHP ◆◆ ◈◈◈◈◈◈◈	Address BCHP Interconnection ◆ ◈◈◈◈◈◈◈◈ - Assess net metering hardware and practices for BCHP - Create pre-certified standards for manufacturers - Establish “quality” guidelines for BCHP (e.g. noise, frequency) - Shorten approval times - Identify unique BCHP needs and issues equipment	Implement “public goods” wires charge to cover investments in BCHP	Educate facilities managers, design community, and A&Es on BCHP benefits ◈◈◈◈
Recognize source energy savings from BCHP as credit in air permitting process ◈◈◈ - Adopt output-based standards	Identify and remover barriers to BCHP in federal facilities ◈◈	Establish tax credits and other financial incentives to users of BCHP where appropriate ◈◈◈◈◈◈ - Support depreciation policies - Implement at federal and state levels	Create “model” rate design for BCHP ◆◆ ◈◈◈◈◈◈ - Present to NARUC and the states - Include criteria for reasonable back-up fees and stranded asset charges - Address issue of fixed versus variable cost allocations for T&D	Promote RD&D in BCHP systems	Fund case studies, field tests, and demonstrations of BCHP ◈◈◈◈
Industry submit draft BCHP bill to Congress ◈◈	Require DOD to evaluate BCHP as part of privatization efforts	Ask NARUC to adopt resolutions at their annual conventions for utilities to provide financial incentives to BCHP	Study BCHP-utility grid impacts	Enact state legislation promoting BCHP in government facilities	Hold executive level seminar on BCHP for LDC senior management

◆ = High Priority; ◈ = Priority

Action Plans

For top priority actions, what needs to be done, by whom, by when, and with what resources?
The first action involves addressing BCHP interconnection issues. The basic approach would be to collaborate with on-going efforts, particularly those underway by the Distributed Power Coalition of America (DPCA). Representatives from the BCHP initiative would review materials that have been prepared by the DPCA for the interconnection of other distributed power technologies and would identify additional requirements that might be needed for the interconnection of BCHP systems.

The goal of this action is to develop a unified approach for interconnection of BCHP systems that is consistent with the approach being followed by DPCA and others such as NREL and IEEE for implementation of standardized interconnection protocols for all types of distributed energy resources. This effort to collaborate on interconnection issues needs to start as soon as possible.

The second action involves creation of an Executive Order on BCHP. The concept is to begin the process of preparing materials on BCHP suitable for inclusion in an Executive Order to be issued by the next administration. The Executive Order would include goals for BCHP, both for federal facilities and the nation as a whole. It would also cover demonstrations of BCHP systems using federal facilities as the "test bed." This BCHP Executive Order would be consistent with existing orders covering energy use in federal facilities and other administration efforts on combined heat and power systems, such as the CHP Challenge.

One of the first steps would be to draft a "white paper" on BCHP that outlines national benefits and provides the rationale for an Executive Order. Along with this paper would be development of a "briefing book" of materials on the BCHP Initiative, describing it and providing concise summaries of the Vision and Roadmap process, technology development requirements and plans, and technical descriptions of the technologies and equipment. The briefing book would supplement the white paper and would be used to educate new officials of the next administration. At the same time, an effort would be started to coordinate with the Federal Energy Management Program (FEMP). BCHP Initiative would lead this action with technical support from national labs and others, as needed. Approximately $100,000 of existing resources would be needed to accomplish the initial tasks. Funding for implementation of the Executive Order, once it has been issued, could be substantial.

The third action requires new ideas and creative thinking to develop incentives for the electric utility industry to embrace BCHP, or at least be less antagonistic toward BCHP development. This effort would be led by a subgroup of the BCHP Initiative, which would hold a small meeting to review mechanisms such as performance-based regulation for utilities. Part of the effort would involve discussions with key staff from utilities that have been supportive of BCHP to determine if there are approaches that could be tried with other utilities. The American Gas Cooling Center (AGCC) volunteered to lead the effort and sponsor the initial meeting to evaluate ideas. This action would cover two years of activities and studies and cost approximately $300,000.

The fourth action involves development of a "model" rate design for BCHP systems. The model would cover general principles and guidelines for stand-by charges, back-up power rates, exit fees, T&D pricing, and competitive transition charges. The model rate design would be proposed to NARUC and used in state proceedings across the country. The model rate design would be developed in collaboration with the DPCA. A subgroup would include volunteers from the BCHP Initiative. This subgroup would review rate design materials that have been prepared by the DPCA. Discussions would be held to develop a unified DPCA-BCHP position on rate design guidelines. Studies would be undertaken to determine BCHP-specific rate design issues, including possibilities for reducing peak power requirements using gas cooling and dehumidification technologies.

A near term target exists to develop information for regulatory hearings in New York and California. However, the analysis required for this could take several years to complete. The American Gas Cooling Center volunteered to lead the initial activities. The cost of the entire effort over two years is estimated to be approximately $500,000.

Action Plans – Administrative Actions and Utility Policy/Practices

Action	Brief Description	Key Tasks	Schedule	Lead	Resource Requirements
Address BCHP Interconnection	Collaborate with DPCA and others to support standardized interconnection protocols	Review DPCA interconnection materials Identify unique BCHP aspects Collaborate to develop unified approaches/ strategies	Start ASAP and prepare for the April 2000 NARUC meeting on distributed energy resources in Philadelphia Longer term effort to be explored later	DPCA leads this effort with BCHP team members providing technical support, as appropriate	Use existing expertise and resources to address near-term needs
Establish BCHP Executive Order	Prepare materials and strategies for an Executive Order by the next Administration. Establish national and federal goals for BCHP. Include demonstrations in federal facilities	Write a position paper on BCHP Prepare BCHP briefing book Prepare draft Executive Order covering interagency task forces and public-private partnerships Coordinate with FEMP	Start preparation of position papers and briefing book ASAP Target incoming Administration and transition team Continue for at least-one year	DOE BCHP program to champion with support from BCHP members	Use existing resources (100K) and expertise to start Implementation of the Executive Order could be very costly
Develop financial mechanisms for the electric power industry to embrace BCHP	Launch a project to identify ways to provide incentives to electric utilities for promoting BCHP.	Form BCHP subgroup and coordinate with DPCA Hold small "brainstorming" session Study PBR, electric peak shaving with gas, emissions credits for BCHP Examine implications of recent EPA-CAAA law suits Involve "friendly" electrics, e.g. (NISOURCE, SDG&E, DE)	Hold brainstorming session ASAP Overall effort for 2 years	AGCC to lead BCHP subgroup	Use existing resources with support from DPCA Overall needs of $300K

Action Plans

For topic priority actions, what needs to be done, by whom, by when, and with what resources?
The first action involves development and passage of an Executive Order that recognizes combined heat and power as a key element in solving climate change issues, reducing dependence on OPEC, and improving grid reliability. The Executive Order would address the need to view BCHP and combined heat and power (CHP) as a source of primary energy, rather than only an interesting energy efficiency opportunity.

The first step in the Executive Order process is to assemble the right constituencies to educate policy makers on the need for the order. Such constituencies include many of the same interests identified in Chapter III: administrative agencies, utilities, building trade organizations and associations, state energy and environmental organizations, building companies, equipment companies and associations, professional consultants, universities, etc. Creating a movement for an Executive Order would need to start soon and continue through the fall of 2000, starting with development of a Working Group to serve a leadership role. This group, composed of the U.S. Combined Heating and Power Association (U.S. CHPA), the BCHP Initiative, the Distributed Power Coalition of America (DPCA), and the American Gas Cooling Center (AGCC), would require about $200,000 to create an educational program and work with the Executive branch of government.

The second action builds on the first, and involves seeking congressional redefinition of all efficiency program goals to recognize primary energy. The purpose of this is to recognize the value of energy produced by cogeneration. By comparing energy value at its source, CHP and BCHP become more cost-competitive with other energy generation technologies. Once the Executive Order is signed, involved constituencies would work with Congress to enact legislation that would change the definition of energy efficiency in all existing energy statues, including EPACT. This effort would continue through 2020, at a cost of $1.5 million. It would need to be led by the White House, with the involvement of the Working Group, DOE, and the many constituencies identified in the BCHP Policy Coordination Matrix.
The third action involves development of baseline measurements that categorize the benefits of BCHP components and systems. To undertake this task would require that existing building systems be categorized. Case studies of BCHP projects would need to be conducted, and primary energy measured. A protocol for data evaluation would then need to be developed and model policies (e.g., from site to primary source) developed. DOE would be requested to take the lead, supported by national laboratories and R&D organizations. Participants in the breakout session estimated that $500,000 would need to be spent to categorize existing systems over a one-year period. Development of new BCHP baseline scenarios would require at least five years.

Policy and Regulations Destination

Highway

Energy Policy and Building Codes and Standards

Components of BCHP technology exists today that can be economically installed and operated, but certain regulatory practices and policy voids are a deterrent. These are clear and present dangers, for BCHP implementation, that need to be addressed through the executive and legislative branches.

BCHP must reach a time and place where the agencies seeking to promote it have developed regulations, standards and policies that are supportive of BCHP.

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Develop the following Federal, State and Industry regulations, standards and or templates:

- Federal standard safety template for BCHP to GRID interconnection.
- IEEE standard for BCHP to GRID interconnection.
- Industry standard contract template for BCHP to GRID interconnection.
- National BCHP Testing Certification Program
- FERC, DOE and other agencies include BCHP as "Green Energy" option with favorable tax status, fees and incentives
- Implement BCHP RD&D tax incentive
- Change EIA reporting to directly link energy efficiency with natural resource conservation.
- EPA to issue standard BCHP fast track permitting process and encourage the use of BCHP throughout the country.

Impact & Timeframe

1 1

Policy always leads the way, but implementation is the key to success. Industry has identified key roadblocks that will prevent a BCHP trip from beginning. These roadblocks will take some time and a lot of effort to be removed.

It is essential for success to quickly eliminate these barriers and construct incentives.

Actions to Address Energy Policy and Building Codes and Standards

What key actions are needed to address energy policy and building codes and standards so that they enhance utilization of BCHP systems?

Development of codes and standards that would effectively like energy use with fuel usage and inevitable emissions occurring from any electrical or mechanical work is a very high priority. Administrative actions that impact climate change and energy use are a high priority, as are legislative actions, construction of demonstration BCHP facilities, and collection of information on the benefits of BCHP, and education and outreach.

- Performance and safety standards need to be created for new BCHP technologies. Performance standards for all energy consuming technologies need to be revisited to reflect efficiency links to energy cost and climate change impact.
- There is support for revising ASHRAE 90.1 and 90.2 building performance standards to reflect efficiency links to energy cost and climate change impact, and to specifically reference BCHP components and systems.
- Codes need to be created for new technologies seeking to become viable products in the marketplace. It should be recognized that the codification process is lengthy and when assessing it from completion of test and safety standards, can take five or more years to complete. Therefore, the code process should begin no later than a technology's early development stage, which is rarely the case.

Proposed administrative actions:

- DOE should initiate development of energy standards, based on the Model Energy Code. A consensus standard would then be developed for source energy, to be utilized by energy developers, whether or not that energy results from cogeneration.
- EPA "New Source Review" standard should apply to any energy consuming device (above a certain threshold size) weather powered by a natural resource (natural gas, oil, coal, etc.) or by a form of energy (electricity, steam, etc.), thus measuring the actual emissions impact to a regions where the new device is used.
- The Climate Change Initiative should strongly link energy use with CO_2 emissions. This can only be achieved by linking all uses of energy with their respective consumption of natural or renewable resources.
- BCHP should be specifically declared as essential to curbing CO_2 emissions.
- EIA reporting DER generation use.
- Revision of the Federal Energy Management Program (FEMP) energy efficiency scoring system to account for primary energy.

There is support for legislative actions that will foster enhanced BCHP development. A high priority is for industry to seek congressional redefinition of all efficiency program goals in terms of primary energy. In this way, energy efficiency actions would be compared on an equal basis, thus moving BCHP into a more favorable light with other energy efficiency activities.

Support continues for demonstration projects and information gathering on BCHP benefits. Throughout the Roadmap process, all participants in all workshops have recommended demonstration of BCHP components, systems, processes, and products. Again, from a policy perspective, demonstration projects provide a vehicle for clearly showing the benefits of BCHP. Similarly, education and outreach are important for moving energy codes for BCHP forward.

Development of consensus standards for BCHP equipment and systems that could then be integrated into building code language could provide the momentum needed to encourage building designers and engineers to use BCHP. Consensus standards require time and effort from all elements of the building industry, but successful completion would propel BCHP into the mainstream of building design and construction. Because of the time required for consensus standards, participants in the session recommended implementation of a “short path” to develop a list of accepted BCHP equipment and systems. Movement along this path would require listing all possible BCHP components and systems, acceptable design, packaging, and use, and guidance for installation and maintenance.

Concurrently, BCHP model code work must begin. Such codes would require tighter indoor air quality control, and include power generation and heat recovery technologies, as well as utilization of generated power within the building and at the building site, leaving no excess for the power grid.

Education and outreach is a key action item for building codes and standards work. Workshops on distributed energy resource codes and standards, modeled on prior workshops related to fuel cells in buildings, would provide training for builders, designers, architects, energy engineers, and others involved in the building environment. A “summit” on BCHP codes and standards could provide the impetus for a fast track approach to the standards.

List of Actions - Energy Policy

Code/ Standard Development	Administrative Actions	Legislative Actions	Demos/ Information Gathering	Education/ Outreach
DER equipment rating & certification based on primary energy ◆✛✛✛	Administration's Climate Change Initiative links source energy to global warming emissions reductions ◆◆✛✛✛	DOE to seek congressional redefinition of all efficiency program goals to primary energy basis ◆✛✛✛✛	Baseline BCHP benefits ◆◆✛✛✛✛✛✛	NASEO presentation on BCHP ✛
DOE to initiate development of primary energy based on Model Energy Code ✛✛✛✛	BCHP declared by DOE as essential tool to reduce primary energy use and curb CO_2 emissions ✛✛✛✛✛✛	Site/source in emission credits	Bid BCHP project demos to State Energy Offices	Develop common definitions
Consensus standard on source energy calculations ◆	DOE – Refuse to adopt ASHRAE 90.1-2000 under EPACT ◆	Amend EPACT '92 to specifically require source energy criteria in federal support for voluntary building standards	Improve Cost Effectiveness	Identify all energy types
Develop DER equipment performance standards (GEN & HR equipment) ✛	EIA to report only source/ primary energy	CO_2 trading		
Revise ASHRAE 90.1 and 90.2 to be source- energy based and reference BCHP systems and equipment	Realignment of efficiency standards/ awards to a "primary energy" basis			
Revise IECC energy code criteria to include source energy	EPA output based standards enacted			
Consensus standard on source fuel/ carbon emission calculation	DOE-FEMP to change federal building energy efficiency scoring system to primary energy			
Safety	EPA new source review based upon all sources of emissions			

◆ = High Priority; ✛ = Priority

Building Codes and Standards Actions

Executive Orders	Develop Codes/ Standards	Equipment Listings	Data/Info Gathering	Education/ Outreach
Fed, state, local requirement by all government agencies to evaluate mission critical application cost in capital purchase ⌖	Conceptualize BCHP model code immediately ⌖⌖⌖⌖	Develop consensus standards for all systems and equipment – for code reference ◆◆◆⌖⌖⌖⌖	Baseline all international BCHP codes ⌖⌖⌖⌖	Workshops for DER codes/ standards modeled after fuel cell example ◆◆ ⌖⌖⌖⌖⌖⌖
Government incentives for payback on major city building projects	Building codes that require tighter IAQ control with 45-50% RH (for example) ⌖⌖⌖	Implement short path to achieve "listed" BCHP Equip/Pkgs ◆◆◆⌖⌖	Identify standards meeting BCHP definition (not internal combustion engine standby)	BCHP codes and standards "summit" ⌖
DOE-FEMP – All new federal buildings and rehabilitation projects must be BCHP	Begin building code process Revise model codes to reference BCHP systems/ equipment ⌖⌖	Develop safety/ performance standards on packaged BCHP units ⌖⌖	Define building type	Engage/educate architectural/ building organizations on BCHP benefits and initiatives
	Initiate effort to include references to power generation and heat recovery technologies in building codes and standards ⌖⌖	Fill voids in safety and performance testing standards on components		Focus on regional or state building code authorities as early adopters of BCHP systems
	Self reliant buildings/no excess ⌖	Safety		
	Inter-connection standards			
	Building codes that address vapor barriers to prevent mildew and mold growing in wall space			
	Define building type			
	Site location (distributed from end use)			

◆ = High Priority; ⌖ = Priority

Action Plans

For topic priority actions, what needs to be done, by whom, by when, and with what resources?

The first action plan involves developing building codes and standards for BCHP. A first task involves development of baseline codes and standards, to be used by architects, building designers, and construction professionals, and implemented by state and local building code officials. The second task involves convening proponents of new codes and standards to craft model BCHP building codes and standards. Building code organizations that are favorable to new ideas and technologies must be part of this consensus process. The consensus standards process is long and tedious; completing this process will take commitment among the members.

Development of equipment and systems standards and certification procedures is the final task of this effort. This action plan is proposed to begin immediately and continue through 2005. The BCHP Initiative, with DOE acting as a catalyst, is recommended as the lead organization for this effort, supported by universities, ASHRAE, building code organizations, regulatory and research arms of government, utilities, standards organizations such as ANSI, and members of the building industry. An estimated level of effort for this action is $1.75 million, over five years of work.

The second action involves fast track building codes and standards work. Based on existing information on BCHP components and systems that is already published and readily available, BCHP building code procedures would be developed in the form of engineering reports, while the codes and standards consensus process proceeds. The Department of Energy would take the lead, with support from the same organizations noted in the previous task (above), starting immediately and continuing for a 2-3 year period, at a cost of $500,000.

The third action pan involves conduct of education programs that provide building code officials with the information and training needed to fairly evaluate BCHP components and systems in both new and existing building designs. Workshops, training seminars, and short courses are suggested as appropriate training environments, and would be even more acceptable if held in conjunction with education programs offered by other organizations (such as ASHRAE, NAHB, etc.). Key tasks include planning and executing these training activities, either independently or in conjunction with other organizations. DOE, working cooperatively with partner organizations, such as ASHRAE, the U.S. CHPA, DPCA, BOMA and other building code organizations, and state energy organizations, would sponsor these training programs. The first such program is the Advanced Building Systems Technology (ABST) 2000 conference scheduled for June 6-8, 2000; additional programs should follow. The estimated cost of the codes and standards education effort is $400,000 per year.

Action Plans – Energy Policy

Action	Key Tasks	Schedule	Lead Organization(s)	Resource Requirements
Administration backs primary energy and BCHP	Draft Executive Order – CHP a key element in solving climate change issues and reducing dependence on OPEC and improving grid reliability Assemble constituencies to educate policy makers	Now - Fall 2000	Working group – USCHPA, BCHP, DPCA, AGCC	$200,000
Seek congressional redefinition of all efficiency programs goals to primary energy basis	Complete activities of Executive Order Develop constituencies to educate congress Enact legislation (change definition in all existing legislatures (NAAACA, EPACT)	After completion of 1 & 2 above – 2020	White House	$1.5 million
Baseline BCHP benefits	Categorize existing systems Conduct case studies Primary energy metric Data evaluation protocol Develop model policies	Existing: 1 year New: 5 years	DOE	Existing: $500,000

Action Plans – Building Codes and Standards

Action	Key Tasks	Schedule	Lead Organization(s)	Resource Requirements
Develop consensus standards for BCHP components and systems	Baseline existing standards Convene technology standards proponents Craft model standards Select favorable standards organizations Complete consensus standards process Equipment/ systems certification listings	Now – 2005 (ongoing work)	BCHP Initiative with DOE catalyst	$1,750,000
Fast track code official approval	Engineering reports	Now – 2002 (ongoing work)	DOE	$500,000
Education programs: summits, workshops, short courses, etc.	Plan and execute programs Invite “right” people Partner with other education programs	June 6, 2000 (ongoing work)	DOE/cost-shared organizations	$400,000 per year

Policy Workshop Conclusions

Workshop participants support moving ahead speedily to implement the recommendations of the previously held technology and process workshops, and, based on the output from this policy workshop, moving ahead as well in the policy/institutional/regulatory arena. Obtaining support for this is a difficult and time consuming process, particularly insofar as regulatory and administrative actions are concerned. A number of trade associations, professional societies, and industry groups are already involved in addressing policy and regulatory barriers regarding the use of BCHP systems. The BCHP Initiative can support these existing efforts and provide information that is specific to the problems faced in installation of advanced cooling, heating, and power systems in the buildings sector. Many of the recommended actions require state decision-making authority, where federal agencies, such as DOE, have a limited role. There is support, however, for developing (and maintaining, where appropriate) federal-state cooperative efforts in the areas of improved interconnection standards for electricity transmission and distribution, more positive tax treatment for BCHP, model tariffs for BCHP sales on the utility grid, and education and training on many of the policy issues raised at the workshop.